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DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

BULLETIN 342

RESULTS
OF
SPIRIT LEVELING IN CALIFORNIA
1896 TO 1907, INCLUSIVE

BY
S. S. GANNETT AND D. H. BALDWIN



WASHINGTON
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YSAHEL GORRATZ

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RESULTS OF SPIRIT LEVELING IN CALIFORNIA FOR THE YEARS 1896 TO 1907, INCLUSIVE.

By S. S. GANNETT and D. H. BALDWIN.

INTRODUCTION.

All results of spirit leveling in California for the years 1896 to May, 1907, including that previously reported upon in Appendixes to Reports of the Director of the United States Geological Survey and in Bulletin No. 185 are herein given, readjusted and rearranged by quadrangles. Descriptions and elevations of bench marks are given for 42 counties, furnishing vertical control for one-third of the State. The leveling since 1903 in the Sacramento Valley, in Colusa, Contra Costa, Glenn, Sacramento, Solano, San Joaquin, Tehama, and Yolo counties, was done in cooperation with the State.

The field work was done under the direction of Mr. R. U. Goode, geographer, 1896 to June, 1903, and under Mr. E. M. Douglas, geographer, since that date. The work of 1904 to 1907, inclusive, was mostly done under the immediate supervision of Mr. R. B. Marshall, geographer, chief of section. Credit is given in the heading of each list to the various topographers and levelmen directly in charge.

The office work of adjustment was done principally by Messrs. L. C. Fletcher and D. H. Baldwin, topographers, under the supervision of Mr. S. S. Gannett, geographer in charge of the triangulation and computing section.

The lists are separated into two classes, precise and primary, distinguishing the degree of refinement in the method of leveling employed. The elevations under precise leveling were determined by lines run either in both forward and backward directions or by simultaneous double-rodged lines, a high-grade level and rated rods being used and special precautions being taken in observation and reduction to correct error and make the results continuously good; elevations under primary leveling were determined mostly by single lines

run with prism or with Y level in circuits required to close within a limiting error represented in feet by the formula $0.05 \sqrt{D}$ in which D is the length of circuit in miles. The lines of precise leveling in this State have been run under different restrictions, and are therefore of slightly different grades of accuracy. The lines Barstow to Mohave and Mohave to Laws and Oasis were run under the same method as now used by the United States Coast and Geodetic Survey except that on the former yard rods instead of metric rods were used and the computation was made in feet from three thread readings, and on the latter a different type of instrument was used and the limit of error and lengths of sections were greater. The limits on these lines are expressed respectively by $0.017 \sqrt{D}$ (equivalent to United States Coast and Geodetic Survey limit) and $0.03 \sqrt{D}$ in which D is distance between bench marks in miles. The lines from Benicia to Pacoima and to the Oregon line were run as simultaneous double-rodded lines with rod correction made for normal temperature and the partial divergence required to keep within a limit in feet represented by the formula $0.03 \sqrt{2D}$ or $0.04 \sqrt{D}$ in which D is distance between bench marks in miles.

The various groups of level lines are all based upon mean sea level, but between certain lists there are outstanding errors of closure which can not be adjusted satisfactorily until more field work is done.

The bench marks described in the following lists are of three general forms. First, a circular bronze or aluminum tablet $3\frac{1}{2}$ inches in diameter and one-fourth inch thick, appropriately lettered, having a 3-inch stem cemented into a drill hole, generally in the vertical walls of public buildings, bridge abutments, or other substantial masonry structures. The second form, employed where masonry or rock is not accessible, consists of a hollow wrought-iron post $3\frac{1}{2}$ inches in outer diameter, 4 feet long after being split and expanded at bottom to 10 inches, so as to prevent both the easy subsidence of the post and its being maliciously pulled out of the ground. The iron is heavily coated with asphalt, and over the top of the post is riveted a bronze tablet similar to that described above. The third form (used in 1896 and 1897) was a copper bolt 4 inches long and 1 inch in diameter fastened into masonry or solid rock by driving it on a brass wedge in the bottom of a vertical hole, so that the top of the bolt was horizontal and thus formed a bench mark.

Numbers stamped upon the bench marks described in the following lists represent the elevations, to the nearest foot above mean sea level, as determined by unadjusted levels in the field. In some cases the finally accepted elevations as printed herein, resulting from the adjustments necessary to close circuits and from reduction to mean sea level through readjustment of the precise-level net, differ from the

bench-mark numbers by several feet. This method of numbering bench marks has been adopted where many levelers are working in the same area at the same time, as less liable to lead to confusion in identification of bench marks, and at the same time giving an approximate statement of elevation. Serial numbering is employed on special lines. It is assumed that engineers and others finding these bench marks so stamped in the field will communicate with the Director of the United States Geological Survey in order to obtain the accepted elevation to hundredths or thousandths of a foot.

Any person finding bench marks in the following lists mutilated or destroyed will confer a favor by notifying the Director, United States Geological Survey, Washington, D. C.

PRECISE LEVELING.

BARSTOW, KRAMER, MOHAVE, AND PALMDALE QUADRANGLES.

KERN AND SAN BERNARDINO COUNTIES.

The elevations in the following list are the adjusted result of a line of precise leveling run between Barstow and Mohave in 1906 by Mr. L. F. Biggs, levelman. The elevation accepted at Barstow is that determined by unadjusted precise leveling of 1906 by the United States Coast and Geodetic Survey from San Diego, and the elevation at Mohave is that determined by an adjustment made in January, 1907, taking account of this line, the precise line of 1901 and 1902 from Benicia to Pacoima, to which it was found necessary to apply an additional rod correction of 0.0006 foot, per vertical foot (increasing differences of elevation), on account of rerunning, and the double-rodged primary line between Pacoima and a bench mark at San Bernardino recovered by the Coast and Geodetic Survey line. The adjustment lowers the elevation at Mohave by this line 0.361 foot with respect to Barstow, this discrepancy being distributed over the total distance of 70 miles.

The instruments used were two self-reading rods $3\frac{1}{2}$ yards in length, graduated to yards and hundredths and reading by estimation to thousandths, and a precise level of the Coast and Geodetic Survey type.

The method adopted was that now used by the United States Coast and Geodetic Survey. The line was broken by temporary bench marks into sections about 1 mile in length; each section was leveled independently in both forward and backward directions, and on all sections upon which the forward and backward measures computed in feet differed by more than $0.017 \sqrt{D}$ (in which D is the distance in miles between bench marks), forward and backward measures were repeated until a pair run in opposite directions fell within the limit.

BARSTOW, ALONG ATCHISON, TOPEKA AND SANTA FE RAILROAD, TO MOHAVE.

BARSTOW QUADRANGLE.

	Feet.
Barstow, 705 feet west of station, 2½ telegraph poles east of milepost 747, 115 feet north of track, on land of Charles O'Donnell, in fence corner; bottom of a square hole in top of cement post projecting 6 inches above ground (established by U. S. Coast and Geodetic Survey)-----	2, 101. 707
Barstow, on railroad right of way, at south end of viaduct over track, northwest corner of west concrete foundation; red metal U. S. C. & G. S. tablet-----	2, 111. 117
Barstow, 2 miles west of, 16 feet north of milepost 749; iron post----	2, 139. 368
Barstow, 5 miles west of, 6 feet north of milepost 752; iron post----	2, 173. 522
Barstow, 8 miles west of, 6 feet north of milepost 755; iron post----	2, 174. 841
Barstow, 11 miles west of, 6 feet north of milepost 758; iron post----	2, 178. 755
Barstow, 14 miles west of, 6 feet north of milepost 761; iron post----	2, 185. 492
Kramer, 16 miles east of, 6 feet north of milepost 764; iron post-----	2, 246. 929
Hiawatha, in front of station; top of rail-----	2, 281. 1
Kramer, 13 miles east of, 6 feet north of milepost 767; iron post----	2, 280. 739
Kramer, 10 miles east of, 6 feet north of milepost 770; iron post-----	2, 367. 936
Kramer, 7 miles east of, 6 feet north of milepost 773; iron post-----	2, 422. 518
Kramer, 4 miles east of, 6 feet north of milepost 776; iron post-----	2, 455. 767

KRAMER QUADRANGLE.

Kramer, 1 mile east of, 6 feet north of milepost 779; iron post-----	2, 482. 885
Kramer, 2 miles west of, 6 feet north of milepost 782; iron post----	2, 509. 442
Kramer, 5 miles west of, 6 feet north of milepost 785; iron post----	2, 435. 951
Kramer, 8 miles west of, 6 feet north of milepost 788; iron post-----	2, 374. 398
Rich, in front of station; top of rail-----	2, 347. 0
Rodriguez, 7 miles east of, 6 feet north of milepost 791; iron post---	2, 280. 769
Rodriguez, 4 miles east of, 6 feet north of milepost 794; iron post---	2, 275. 240
Rodriguez, 1 mile east of, 6 feet north of milepost 797; iron post---	2, 272. 326
Rodriguez, in front of station; top of rail-----	2, 286. 248
Rodriguez, 2 miles northwest of, 6 feet north of milepost 800; iron post-----	2, 321. 563
Rodriguez, 5 miles northwest of, 6 feet north of milepost 803; iron post-----	2, 370. 300

PALMDALE QUADRANGLE.

Rodriguez, 8 miles northwest of, 6 feet north of milepost 806; iron post-----	2, 420. 435
Bissell, in front of station; top of rail-----	2, 450. 7
Mohave, 9 miles southeast of, 6 feet north of milepost 809; iron post--	2, 462. 194

MOHAVE QUADRANGLE.

Mohave, 6 miles southeast of, 4 feet north of milepost 812; iron post--	2, 541. 179
Mohave, 3 miles southeast of, 10 feet north of milepost 815; iron post--	2, 618. 240
Mohave, 0.4 mile south of, 25 feet north of milepost 382, west of track; iron post-----	2, 733. 451

BALLARAT, BISHOP, LIDA, MOHAVE, MOUNT WHITNEY, PILOT PEAK, AND OLANCHA QUADRANGLES.

KEEN AND INYO COUNTIES.

The following elevations are the results of a spur line of precise levels run in the spring of 1905 by Mr. R. A. Farmer, topographer, northward from Mohave along stage road to Keeler, thence along the Carson and Colorado Railway to Laws, and from Alvord northeast to the State line near Oasis.

The instruments used were a Buff & Berger level and two self-reading rods, 3.1 meters in length, graduated to centimeters and reading by estimation to millimeters.

The method adopted was a modification of that now used by the Coast and Geodetic Survey. The line was broken by temporary bench marks into sections 2 to 3 kilometers in length; each section was leveled independently in the forward and backward directions, and on all sections upon which the forward and backward measures differed by more than $8\sqrt{K}$ millimeters (which is twice the U. S. C. & G. S. limit generally used), in which K is the distances between adjacent bench marks in kilometers, both the forward and backward measures were repeated until such measures fell within this limit.

The initial bench mark is an iron post stamped "2732 B," 0.4 mile south of Mohave, 25 feet north of milepost 382, the elevation of which is now accepted as 2,733.451 feet above mean sea level.

MOHAVE, NORTHWARD ALONG STAGE ROAD, TO KEELER.

MOHAVE QUADRANGLE.

	Feet.
Mohave, 0.4 mile south of, 25 feet north of milepost 382, west of track; iron post stamped "2732 B"-----	2, 733. 451
Mohave, 3.5 miles northeast of, 10 feet south of road; iron post stamped "2955 B"-----	2, 957. 090
Mohave-Tehachapi-Randsburg signboard, 1.1 miles northeast of, 10 feet south of road; iron post stamped "2745 B"-----	2, 746. 614
Mohave-Tehachapi-Randsburg signboard, 4.3 miles northeast of, 10 feet east of road; iron post stamped "2588 B"-----	2, 589. 830
Mohave-Tehachapi-Randsburg signboard, 7.3 miles northeast of, 10 feet east of road; iron post stamped "2419 B"-----	2, 421. 143
Eighteenmile station, 1.8 miles south of, 20 feet east of road, 50 feet east of Copper Mining mail box; iron post stamped "2152 B"-----	2, 154. 019
Eighteenmile station, 1.1 miles north of, 10 feet east of road; iron post stamped "2108 B"-----	2, 110. 231
Eighteenmile station, 4.2 miles north of, 10 feet west of road; iron post stamped "2123 B"-----	2, 125. 038
Ricardo (formerly Red Rock) post-office, 0.7 mile northwest of, 20 feet north of road; iron post stamped "2442 B"-----	2, 443. 624
Ricardo post-office, 3.8 miles northwest of, 40 feet west of road; iron post stamped "2902 B"-----	2, 904. 200
Ricardo post-office, 6.4 miles northwest of, 50 feet west of road, at Summit of Red Rock Canyon; iron post stamped "3520 B"-----	3, 522. 165
Dixie stage station, 1.3 miles southwest of, 10 feet west of road; iron post stamped "3281 B"-----	3, 282. 964

PILOT PEAK QUADRANGLE.

	Feet.
Dixie stage station, 2 miles northeast of, 10 feet east of road; iron post stamped "3172 B"-----	3, 174. 253
Dixie station, 5.3 miles northeast of, 10 feet west of road; iron post stamped "3290 B"-----	3, 292. 257
Freeman, 400 feet south of, 20 feet west of road on hillside south side of Walker Canyon; iron post stamped "3379 B"-----	3, 381. 335
Freeman, 3.2 miles northeast of, 30 feet east of road; iron post stamped "3110 B"-----	3, 111. 837
Indian Wells, 300 feet north of, 20 feet west of road; iron post stamped "B"-----	2, 740. 161
Indian Wells, 3.1 miles north of, 10 feet east of road; iron post stamped "B"-----	2, 698. 352
Indian Wells, 5.9 miles north of, 30 feet west of road; iron post-----	2, 599. 124
Indian Wells, 9.2 miles north of, 40 feet east of road; iron post-----	2, 486. 654
Little Lake, 8.8 miles south of, 40 feet west of road, at summit of granite bowlder; aluminum tablet-----	2, 573. 550
Little Lake, 4.6 miles south of, 70 feet east of road, at summit of granite bowlder; aluminum tablet-----	2, 818. 259
Little Lake, 1.2 miles south of, 10 feet east of road, summit of black bowlder; aluminum tablet-----	2, 947. 774
Little Lake, 1.7 miles north of, 50 feet west of road, at summit of granite bowlder; aluminum tablet-----	3, 329. 511
Little Lake, 4.9 miles north of, 50 feet east of dry lake bed, 40 feet east of road, in summit of lava bowlder; aluminum tablet-----	3, 333. 529

BALLARAT QUADRANGLE.

Little Lake, 8.1 miles north of, 40 feet east of road; iron post-----	3, 369. 852
Little Lake, 10.9 miles north of, 25 feet west of road; iron post-----	3, 444. 171
Hawai Meadows, 3.4 miles south of, 80 feet east of road; iron post---	3, 641. 821
Hawai Meadows, 720 feet north of house, 35 feet west of road; iron post-----	3, 734. 101
Hawai Meadows, 3.1 miles north of, 100 feet west of road on hillside, at summit of granite bowlder; aluminum tablet-----	3, 736. 969
Olancha, 2.2 miles south of, 20 feet east of road; iron post-----	3, 716. 886

OLANCHA QUADRANGLE.

Olancha, 2 feet east of post-office porch; iron post-----	3, 649. 391
---	-------------

BALLARAT QUADRANGLE.

Olancha, 3.2 miles northeast of, 20 feet southeast of road; iron post--	3, 619. 361
Olancha, 6.4 miles northeast of, 50 feet northwest of road; iron post--	3, 628. 710
Olancha, 9.4 miles northeast of, 20 feet northwest of road; iron post--	3, 612. 718
Keeler, 6.9 miles southwest of, 30 feet north of road; iron post-----	3, 618. 405
Keeler, 3.4 miles southeast of, 25 feet east of road; iron post-----	3, 631. 009
Keeler, at southeast corner of post-office; iron post-----	3, 610. 307
Keeler, in front of station; top of east rail-----	3, 600. 9
Keeler, 0.5 mile northwest of, 10 feet from road, marble rock cut 1 foot square, 3 feet high, marking azimuth station; top of copper plate at intersection of cross lines-----	3, 599. 480

	Feet.
Keeler, 2.1 miles northwest of, 150 feet south of the Soda Works pipe line, 400 feet east of Owens Lake; iron post.....	3, 570. 235
Owens Lake, 200 feet southeast of Soda Company's pipe; surface of water, March 30, 1905.....	3, 568. 7

KEELER, ALONG CARSON AND COLORADO RAILWAY, TO LAWS.

BALLARAT QUADRANGLE.

Keeler, 3 miles north of, 8 feet north of telegraph pole opposite milepost 290; iron post.....	3, 608. 157
Inyo marble quarry, 1 mile north of, 25 feet north of milepost 287; iron post	3, 674. 699
Inyo quarry, 4 miles north of, 200 feet north of milepost 284; iron post	3, 671. 961

MOUNT WHITNEY QUADRANGLE.

Mount Whitney station, 0.5 mile south of, 100 feet south of milepost 281; iron post.....	3, 681. 507
Mount Whitney station, in front of; top of east rail.....	3, 688. 809
Mount Whitney station, 2.5 miles north of, 3 feet east of track, opposite milepost 278; iron post.....	3, 689. 764
Mount Whitney station, 5.5 miles north of, 10 feet south of milepost 275; iron post.....	3, 717. 763
Francis, in front of station; top of east rail.....	3, 724. 257
Francis, 100 feet northeast of station, east of track; iron post.....	3, 723. 232
Francis, 3 miles north of station, at milepost 269; iron post.....	3, 738. 544
Citrus, in front of station; top of east rail.....	3, 765. 3
Citrus, in front of station; iron post.....	3, 766. 400
Citrus, 3 miles north of station, at milepost 264; iron post.....	3, 764. 016
Citrus, 6 miles north of station; iron post.....	3, 785. 690
Aberdeen, 5 miles south of, 20 feet north of milepost 258; iron post.....	3, 814. 559
Aberdeen, 2 miles south of, at milepost 255; iron post.....	3, 831. 595

BISHOP QUADRANGLE.

Aberdeen, 1 mile north of, at milepost 252; iron post.....	3, 850. 144
Aberdeen, 4 miles north of, 60 feet south of milepost 249; iron post.....	3, 859. 267
Alvord, 6.5 miles south of, at milepost 246; iron post.....	3, 881. 276
Alvord, 3.5 miles south of, at milepost 243; iron post.....	3, 897. 130
Alvord, in front of station; iron post.....	3, 930. 130
Alvord, in front of station; top of rail.....	3, 929. 6
Alvord, 2.5 miles north of, 120 feet south of milepost 237, west of track; iron post.....	3, 952. 144
Alvord, 5.5 miles north of, 100 feet north of milepost 234; iron post.....	3, 981. 047
Alvord, 8.5 miles north of, at milepost 231; iron post.....	4, 007. 490
Alvord, 10.5 miles north of, 150 feet south of milepost 229; iron post.....	4, 035. 106
Laws, 2.5 miles south of, 2 feet south of milepost 226; iron post.....	4, 064. 895
Laws, in front of station; top of east rail.....	4, 112. 7
Laws, in front of station; iron post stamped "B 4116, 1905".....	4, 114. 583
Laws, 2.5 miles north of, at milepost 221; iron post.....	4, 142. 000
Laws, 5.5 miles north of, milepost 218; iron post.....	4, 210. 192

ALVORD, NORTHEAST ALONG COUNTY ROADS, TO OASIS AND STATE LINE.

BISHOP QUADRANGLE.

	Feet.
Alvord, 2.9 miles northeast of, 10 feet north of road, summit of rock 2.5 by 2.5 by 1.5 feet; aluminum tablet-----	4, 502. 388
Alvord, 6.4 miles northeast of, 300 feet southeast of toll house, summit of rock 3 by 3 by 2 feet, aluminum tablet-----	5, 971. 350
Alvord, 10.7 miles northeast of, 20 feet south of road, on summit near cedar tree; iron post-----	7, 276. 225
Payson cabin, 0.5 mile east of, 40 feet east of road; iron post-----	6, 556. 830
Road to Payson's ranch, 10 feet south of road forks; iron post-----	5, 519. 064
Payson's ranch, 5 miles east of, 20 feet north of road; iron post-----	5, 108. 922
Gilbert ranch, 0.7 mile northwest of, 20 feet south of road; iron post--	5, 209. 692
Gilbert ranch, 1.5 miles northeast of, 30 feet north of road; iron post--	5, 314. 341

LIDA QUADRANGLE.

Piper ranch, first summit west of; iron post-----	6, 371. 105
Oasis, 2.5 miles southwest of, at road forks; iron post-----	5, 299. 775
Oasis, northeast corner of post-office wall; bronze tablet stamped "5106 C. C." (old value, 5,106.101.—Appendix to 19th Ann. Report) -	5, 031. 226
Oasis, 3 miles southeast of, 30 feet north of road, 0.25 mile east of forks of road; iron post-----	5, 080. 887

BAKERSFIELD SPECIAL, CARQUINEZ, DAVISVILLE, FAIROAKS, FERNANDO, SANTA SUSANA, TUJUNGA, VACAVILLE, AND WOODLAND 15' QUADRANGLES; BAKERSFIELD, CALIENTE, FAMOSO, FRESNO, HANFORD, LODI, LOS BANOS, MADERA, MERCED, MOHAVE, NAPA, OAKDALE, PALMDALE, SACRAMENTO, STOCKTON, AND VISALIA 30' QUADRANGLES.

FRESNO, KERN, KINGS, LOS ANGELES, MADERA, MERCED, SACRAMENTO, SAN JOAQUIN, SOLANO, STANISLAUS, TULARE, AND YOLO COUNTIES.

The elevations in the following list are based upon a bench mark of the United States Coast and Geodetic Survey, described as the upper surface of a $\frac{3}{8}$ -inch iron bolt driven in a hole drilled horizontally in the southwestern face of a sandstone rock smoothed a foot square, at the top of a ledge near high-water mark at Benicia Arsenal, just south of the railroad and east of the arsenal wharf. The elevation of the bench mark was accepted as 5.980 feet above mean sea level.

The line was originally checked and adjusted by connecting with a bench mark at Pacoima, previously established from the tidal bench mark at San Pedro, and published in Appendix to the Nineteenth Annual Report, page 387, the closure error being -0.243 foot in 523 miles; but the rerunning of a portion of this line near Mohave in 1906 by precise leveling showed that the rods that were used on this line had apparently lengthened 0.0006 foot per vertical foot over their original rating, and the section Tipton to Pacoima has been corrected for this error and adjusted additionally to make a total correction to the previous adjusted height at Mohave of $+2$ feet and of $+0.7$ foot

at Pacoima. The correction at Pacoima is derived through an unadjusted double-rodged primary line of 1896, by H. S. Crowe, from San Bernardino, at which place the elevation determined in 1906 by precise leveling of the Coast and Geodetic Survey from Point Loma (near San Diego) is accepted, and the old elevation of the tidal bench mark at San Pedro disregarded. The Coast and Geodetic Survey gage height at Santa Monica, formerly disregarded but now accepted, makes correction to Crowe's double line at that place $+0.886$ foot. The elevation now adopted at Mohave is 0.36 foot less than that determined from San Bernardino by precise levels of 1906 by the Coast and Geodetic Survey to Barstow, and by United States Geological Survey thence to Mohave, it is 0.25 greater than that brought from San Bernardino via Pacoima using Semper's line corrected for the additional rod error, and 0.52 foot greater than by using Semper's corrected line from Benicia.

The leveling was done in 1901 and 1902 by Mr. C. H. Semper, levelman in charge, using a Buff & Berger precise level and the double simultaneous method.

BENICIA, VIA SOUTHERN PACIFIC RAILROAD, TO SACRAMENTO.

CARQUINEZ 15' (NAPA 30') QUADRANGLE.

	Feet.
Goodyear, in front of station; top of rail-----	7.9
Oluta, in front of station; top of rail-----	5.9
Teal, in front of station; top of rail-----	5.6
Fairfield, at left of main entrance to court-house, 7.5 feet below bottom of stone ledge to first window of auditor's office; bronze tablet stamped "15" ^a -----	15.170

VACAVILLE QUADRANGLE.

Sulsun, 3.9 miles north of, 25 feet east of track, 3 feet south of milepost 53; iron post stamped "47 B"-----	46.833
Vanden, in front of station; top of rail-----	73.4
Canon, 12 feet south of station, 12 feet west of track; iron post stamped "89 B"-----	88.650
Canon, in front of station; top of rail-----	87.8
Canon, 2.6 miles north of, west side of track, 8 feet south of milepost 59; iron post stamped "80 B"-----	80.291
Elmira, in front of station; top of rail-----	75.0
Elmira, 1.7 miles north of, 33 feet east of track, 2 feet west of milepost 62; iron post stamped "62 B"-----	62.282
Batavia, 2 feet from north end of station, 27 feet east of track; iron post stamped "62 B"-----	61.758
Dixon, 700 feet south of station, west side of track, at highway crossing, south side of road, at corner of fence; iron post stamped "61 B"-----	61.295

^a This bench mark was originally established in 1896, the elevation as then determined being 15.151 (See Appendix to 18th Ann. Report, 1896-7, p. 414).

Dixon, in front of station; top of rail-----	Feet. 62.9
Dixon, 2.4 miles north of, east side of track, 3 feet from milepost 71; iron post stamped "58 B"-----	57.618
Tremont, in front of station; top of rail-----	58.9

WOODLAND QUADRANGLE.

Tremont, 1.3 miles north of, east side of track, 5 feet from milepost 74; iron post stamped "49 B"-----	48.890
Davisville, in front of Davis station; top of rail-----	47.4
Davisville, 0.4 mile east of, south side of track, 5 feet from milepost 77; iron post stamped "42 B"-----	42.095
Davisville, 3.3 miles east of, south side of track, 18 feet south of mile- post 80, on fence line; iron post stamped "28 B"-----	27.644
Swingle, in front of station; top of rail-----	28.1
Webster, in front of station; top of rail-----	22.2
Webster, 1.5 miles east of, south side of track, 5 feet west of milepost 83; iron post stamped "14 B"-----	14.060
Milepost 86, 4 feet north by 15 feet east of, south side of track; iron post stamped "17 B"-----	17.339
Broderick, in front of station; top of rail-----	26.3
Broderick, at Third street crossing; top of rail-----	29.3
Sacramento, in front of station; top of rail-----	29.6

SACRAMENTO, VIA SOUTHERN PACIFIC RAILROAD, TO STOCKTON.

DAVISVILLE QUADRANGLE.

Sacramento, at foot of L street, south end of steamer shed; 34 foot mark of the United States Weather Bureau gage (determined by R. A. Farmer, 1905)-----	33.524
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FAIROAKS 15' (SACRAMENTO 30') QUADRANGLE.

Sacramento, 300 feet east of Capitol, in top of surface of meridian stone; aluminum tablet stamped "21 B" (elevation by Coast and Geodetic Survey is 2.876 feet higher)-----	20.865
Sacramento, at Thirteenth street crossing; top of rail-----	21.3
Sacramento, at Twenty-fifth street crossing; top of rail-----	24.0
Brighton, in front of station; top of rail-----	42.4
Brighton, 200 feet south of station, 20 feet west of track, at tele- graph pole; iron post stamped "41 B"-----	41.042
Brighton, 3.2 miles south of, 6 feet south of milepost 131, east side of track; iron post stamped "36 B"-----	35.741

LODI 30' QUADRANGLE.

Florin, 150 feet north of station, at crossing; top of rail-----	39.3
Milepost 127, 4 feet south of, east side of track, at crossing; iron post stamped "37 B"-----	36.740
Elk Grove, on Main street, 30 feet west of track, 4 feet south of street line; iron post stamped "49 B"-----	49.289
Elk Grove, in front of station; top of rail-----	49.4

	Feet.
McConnells, 50 feet north of station, 50 feet east of track; iron post stamped "46 B"-----	46.390
Arno, 50 feet south of station, west side of track, at fence line; iron post stamped "35 B"-----	35.058
Arno, in front of station; top of rail-----	36.9
Milepost 115, 10 feet south of, east side of track; iron post stamped "42 B"-----	41.880
Galt, in front of station; top of rail-----	46.2
Galt, on line with north margin of station, 30 feet west of track; iron post stamped "46 B"-----	45.576
Forest Lake, in front of station; top of rail-----	48.2
Milepost 109, 15 feet north of, east side of track at crossing; iron post stamped "48 B"-----	48.296
Acampo, in front of station; top of rail-----	55.6
Acampo, 1 mile south of, east side of track at crossing, north margin of road; iron post stamped "53 B"-----	52.625
Lodi, in front of station; top of rail-----	50.7
Lodi, 1.5 miles south of, east side of track, at crossing, north side of road at angle of fence; iron post stamped "45 B"-----	45.286
Milepost 100, 5 feet south of, east side of track at fence line; iron post stamped "37 B"-----	37.430
Milepost 97, 15 feet north of, east side of track, at fence line; iron post stamped "28 B"-----	28.111

STOCKTON QUADRANGLE.

Milepost 94, 8 feet north of, east side of track, on fence line; iron post stamped "20 B"-----	20.075
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STOCKTON, VIA SOUTHERN PACIFIC RAILROAD, TO FRESNO.

STOCKTON QUADRANGLE.

Stockton, at Park street crossing; top of rail-----	18.6
Stockton, west door of north entrance of San Joaquin County courthouse, in angle of wall; bronze tablet stamped "18 B" ^a -----	17.953
Stockton, in front of station; top of rail-----	18.8
Stockton, at Sacramento street crossing; top of rail-----	22.0
Stockton, 0.6 mile south of, at crossing of Santa Fe railroad; top of rail-----	21.7
Milepost 88, 8 feet south of, east side of track, at fence line; iron post stamped "15 B"-----	14.679
French Camp, in front of station; top of rail-----	19.4
Milepost 85, 200 feet east of, east side of track, at road crossing, at fence line; iron post stamped "19 B"-----	18.971
Lathrop, 250 feet north of station, at northwest corner of railroad park, on margin of road; iron post stamped "20 B"-----	19.938
Lathrop, in front of station; top of rail-----	21.6
Monteca, 25 feet south of station, 20 feet west of milepost 98, at fence line; iron post stamped "36 B"-----	35.831
Monteca, 2.9 miles south of, 20 feet west of milepost 10, west side of track, at fence line; iron post stamped "45 B"-----	44.998

^a This bench mark was originally established in 1896, the elevation as then determined being 17.461 (see Appendix to 18th Ann. Report, 1896-7, p. 416).

	Feet.
Milepost 104, 50 feet north of, west side of track, at fence line; iron post stamped "61 B"-----	61. 073
Ripon, crossing at station; top of rail-----	67. 5
Ripon, 2.3 miles south of, opposite milepost 107, east side of track, at fence line; iron post stamped "67 B"-----	66. 592
Salida, 2.6 miles south of, opposite milepost 110, east side of track, at fence line; iron post stamped "78 B"-----	77. 567
Milepost 113, opposite, east side of track, at fence line; iron post stamped "82 B"-----	82. 117
Modesto, in front of station; top of rail-----	86. 1
Modesto, in southwest corner of court-house; bronze tablet stamped "91 B"-----	91. 329

OAKDALE QUADRANGLE.

Modesto, 1.6 miles south of, 10 feet south of milepost 116, west side of track, at fence line; iron post stamped "86 B"-----	86. 184
Ceres, in front of station; top of rail-----	88. 4
Esmar, in front of station; top of rail-----	93. 4
Keyes, opposite milepost 122, 75 feet east of side track, on west margin of highway; iron post stamped "92 B"-----	92. 408
Keyes, 2.9 miles south of, opposite milepost 125, east side of track, at fence line; iron post stamped "100 B"-----	100. 214
Turlock, in front of station; top of rail-----	101. 1

LOS BANOS QUADRANGLE.

Turlock, 0.6 mile south of, opposite milepost 128, on east margin of highway; iron post stamped "103 B"-----	102. 952
Turlock, 3.6 miles south of, 5 feet north of milepost 131, west side of track; iron post stamped "111 B"-----	111. 290
Milepost 134, 27 feet south of; iron post stamped "116 B"-----	116. 456
Milepost 137, 5 feet north of, west side of track, at fence line; iron post stamped "129 B"-----	128. 818
Livingston, in front of station; top of rail-----	130. 6
Livingston, 2.5 miles south of, opposite milepost 140, east side of track, at margin of highway; iron post stamped "142 B"-----	141. 839
Arena, in front of station; top of rail-----	140. 5
Arena, 2.9 miles south of, opposite mile post 143, east side of track, at fence line; iron post stamped "154 B"-----	153. 877
Atwater, in front of station; top of rail-----	147. 7
Buhach, 60 feet north of station, opposite milepost 146; iron post stamped "153 B"-----	152. 679
Buhach, in front of station; top of rail-----	155. 4
Milepost 149, opposite, east side of track, at margin of road; iron post stamped "154 B"-----	154. 374

MERCED QUADRANGLE.

Merced, in southeast corner of county court-house; aluminum tablet stamped "171 B"-----	171. 118
Merced, 3.2 miles south of, opposite milepost 155, east side of track at margin of highway; iron post stamped "178 B"-----	178. 505

PRECISE LEVELING.

17

	Feet.
Milepost 158, opposite, east side of track, at margin of highway; iron post stamped "187 B"-----	187.587
Milepost 161, opposite east side of track, at margin of highway, iron post stamped "198 B"-----	198.474
Athlone, in front of station; top of rail-----	204.0
Athlone, 2.5 miles south of, opposite milepost 164, east side of track, at margin of highway; iron post stamped "217 B"-----	217.392
Milepost 157, 150 feet south of, east side of track, at margin of highway; iron post stamped "233 B"-----	232.731
Minturn, in front of station; top of rail-----	238.6
Minturn, 1.9 miles south of, opposite milepost 170, east side of track, at margin of highway; iron post stamped "241 B"-----	240.597
Milepost 173, opposite, east side of track, at margin of highway; iron post stamped "247 B"-----	246.703
Milepost 176, opposite, east side of track, at margin of highway; iron post stamped "249 B"-----	249.281
Berenda, in front of station; top of rail-----	250.3
Berenda, 1.3 miles south of, 18 feet south of milepost 179, west of track, at margin of highway; iron post stamped "248 B"-----	248.264
Milepost 182, 15 feet south of, west of side track, at margin of high- way; iron post stamped "270 B"-----	270.432

MADERA QUADRANGLE.

Madera, in front of station; top of rail-----	272.0
Madera, in front face of northeast corner of county court-house; aluminum tablet stamped "274 B"-----	274.030
Borden, in front of station; top of rail-----	269.6
Borden, 1,000 feet south of station, 100 feet south of milepost 188, at corner of fence, west side of track; iron post stamped "269 B"--	269.464

FRESNO QUADRANGLE.

Milepost 191, 8 feet south of, west side of track, at margin of high- way; iron post stamped "273 B"-----	273.972
Milepost 194, 6 feet south of, west side of track, at margin of high- way; iron post stamped "284 B"-----	284.571
Milepost 197, 300 feet south of, 55 feet east of track, at crossing; iron post stamped "300 B"-----	300.150
Milepost 200, 10 feet south of, west side of track, at margin of high- way; iron post stamped "297 B"-----	296.738
Milepost 203, 225 feet south of, west side of track, at margin of high- way; iron post stamped "296 B"-----	295.910
Fresno, in west face of passenger station, south of door to gentle- men's waiting room; aluminum tablet stamped "290 B"-----	289.983

FRESNO, VIA SOUTHERN PACIFIC RAILROAD, TO BAKERSFIELD.

FRESNO QUADRANGLE.

Fresno, opposite south end of passenger station; top of rail of main line-----	287.1
Fresno, 1 mile south of, at Cherry-avenue crossing; top of rail-----	286.3

	Feet.
Fresno, 2.3 miles south of, 14 feet south of milepost 209, west side of track, at margin of highway; iron post stamped "286 B"-----	286.421
Crossing of Santa Fe and Southern Pacific railroads; top of rail----	290.3
Malaga, in front of station, top of rail-----	293.2
Malaga, 0.4 mile south of, 15 feet south of milepost 212, west side of track, at margin of highway; iron post stamped "297 B"-----	297.037
Malaga, 3.5 miles south of, 10 feet south of milepost 215, east side of track, at margin of highway; iron post stamped "300 B"-----	300.465
Fowler, in front of station; top of rail-----	304.1
Fowler, 1.7 miles south of, 12 feet south of milepost 218, west side of track, at margin of highway; iron post stamped "304 B"-----	303.871
Selma, 0.8 mile north of, 11 feet south of milepost 221, west side of track, at margin of highway; iron post stamped "310 B"-----	310.368
Selma, in front of station; top of rail-----	305.8
Selma, 2.2 miles south of, 8 feet south of milepost 224, west side of track, at margin of highway; iron post stamped "305 B"-----	304.755
Kingsburg, in front of station; top of rail-----	296.6
Kingsburg; 0.3 mile south of, opposite milepost 227, west side of track, at margin of highway; iron post stamped "295 B"-----	294.754

HANFORD QUADRANGLE.

Kingsburg, 3 miles south of, 8 feet south of milepost 230, west side of track, at margin of highway; iron post stamped "295 B"-----	295.119
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VISALIA QUADRANGLE.

Traver, in front of station; top of rail-----	285.3
Traver, 0.5 mile south of, 19 feet south of milepost 233, west side of track, at margin of highway; iron post stamped "283 B"-----	282.843
Traver, 3.5 miles south of, 9 feet south of milepost 236, west side of track, at margin of highway; iron post stamped "271 B"-----	271.422
Milepost 239, 10 feet south of, west side of track, at margin of highway; iron post stamped "280 B"-----	278.982
Goshen, in front of station; top of rail-----	283.5
Goshen, 1.4 miles south of, opposite milepost 242, east side of track, at margin of highway; iron post stamped "286 B"-----	286.338
Milepost 245, 10 feet south of, west side of track; iron post stamped "293 B"-----	292.787
Milepost 248, opposite, east side of track, at margin of fence line; iron post stamped "293 B"-----	293.350
Tulare, at crossing of Santa Fe Railway; top of rail-----	288.3
Tulare, 10 feet south of northeast corner of public library fence, 200 feet south of milepost 251, west side of track; iron post stamped "285 B"-----	284.721
Tulare, in front of station; top of rail-----	287.3
Tulare, 2.9 miles south of, 10 feet south of milepost 254, west side of track, at margin of highway; iron post stamped "269 B"-----	269.180
Milepost 257, 4 feet north of, west side of track, at margin of highway fence; iron post stamped "266 B"-----	266.208
Milepost 260, opposite, east side of track, at fence line for east margin of highway; iron post stamped "266 B"-----	266.463
Tipton, in front of station; top of rail-----	272.0

PRECISE LEVELING.

19

	Feet.
Tipton, 1.4 miles south of, east side of track, at fence line, opposite milepost 263; iron post stamped "277 B"-----	277. 271
Tipton, 4.4 miles south of, west side of track, opposite milepost 266; iron post stamped "272 B"-----	272. 616

FAMOSO QUADRANGLE.

Pixley, in front of station; top of rail-----	274. 3
Milepost 269, 15 feet south of, west side of track, at fence line; iron post stamped "275 B"-----	275. 217
Milepost 272, opposite, east side of track, at margin of fence; iron post stamped "276 B"-----	276. 222
Milepost 275, opposite, west side of track, at margin of fence; iron post stamped "293 B"-----	293. 023
Milepost 278, opposite, west side of track, at margin of fence; iron post stamped "303 B"-----	303. 631
Delano, 0.8 mile north of, opposite milepost 281, west side of track at margin of fence; iron post stamped "316 B"-----	316. 644
Delano, in front of station; top of rail-----	318. 7
Delano, 2.1 miles south of, 12 feet south of milepost 284, west side of track; iron post stamped "307 B"-----	307. 151
Milepost 287, 12 feet south of, west side of track, at margin of high- way; iron post stamped "342 B"-----	341. 928
Milepost 290, 12 feet south of, west side of track; iron post stamped "376 B"-----	376. 643
Famoso, 0.7 mile north of, opposite milepost 293, east side of track, at margin of highway; iron post stamped "415 B"-----	415. 479
Famoso, in front of station; top of rail-----	423. 4
Milepost 296, opposite, east side of track, at margin of highway; iron post stamped "439 B"-----	439. 004
Milepost 299, opposite, 45 feet east of track; iron post stamped "442 B"-----	442. 320
Milepost 302, opposite, 40 feet east of track; iron post stamped "415 B"-----	415. 086

BAKERSFIELD SPECIAL (BAKERSFIELD 30') QUADRANGLE.

Milepost 305, opposite, 43 feet east of track; iron post stamped "427 B"-----	427. 798
Jewetta, in front of station; top of rail-----	453. 9
Jewetta, 1 mile southeast of, opposite milepost 308, 40 feet east of track; iron post stamped "448 B"-----	448. 386
Milepost 312, opposite, on east side of track, at fence line; iron post stamped "409 B"-----	409. 937

BAKERSFIELD, VIA SOUTHERN PACIFIC RAILROAD, TO TEHACHAPI.

BAKERSFIELD SPECIAL (CALIENTE 30') QUADRANGLE.

Bakersfield (Kern station), 130 feet east of northeast corner of sta- tion, at south end of highway and corner of fence; iron post stamped "421 B"-----	421. 877
Bakersfield (Kern station), in front of station; top of rail-----	420. 7

CALIENTE 30' QUADRANGLE.

	Feet.
Milepost 317, 12 feet south of, on west side of track, at margin of highway; iron post stamped "431 B"-----	431.898
Milepost 320, 12 feet south of, on west side of track, at margin of highway; iron post stamped "509 B"-----	510.070
Milepost 323, 12 feet south of, on west side of track; iron post stamped "660 B"-----	660.929
Milepost 326, opposite, east side of track, at fence line; iron post stamped "864 B"-----	864.992
Pampa, 30 feet west of station, on east side of track, at fence line; iron post stamped "874 B"-----	874.815
Pampa, in front of station; top of rail-----	875.9
Milepost 332, 370 feet south of, east side of track, at fence line; iron post stamped "1014 B"-----	1,015.446
Milepost 335, 65 feet south of, 10 feet east of track; iron post stamped "1201 B"-----	1,202.070
Caliente, 1.6 miles south of, 10 feet south of milepost 338, on west side of track; iron post stamped "1402 B"-----	1,403.527
Milepost 341, opposite, on east side of track, at margin of fence; iron post stamped "1732 B"-----	1,733.688
Bealville, crossing at station; top of rail-----	1,806.4
Milepost 344, 100 feet north of, 25 feet east of track; iron post stamped "2054 B"-----	2,055.255
Milepost 347, 150 feet south of, 60 feet west of track, 20 feet east of fence; iron post stamped "2395 B"-----	2,396.987
Keene, in front of station; top of rail-----	2,711.7
Keene, 360 feet south of station, 30 feet west of track, at milepost 350; iron post stamped "2719 B"-----	2,721.489
Milepost 353, 360 feet south of, on west side of track, 20 feet south of crossing; iron post stamped "3064 B"-----	3,066.522

MOHAVE QUADRANGLE.

Girard, in front of station; top of rail-----	3,295.6
Girard, 0.9 mile south of, on east side of track, opposite milepost 356, 12 feet from fence; iron post stamped "3396 B"-----	3,398.433

TEHACHAPI, VIA SOUTHERN PACIFIC RAILROAD, TO MOHAVE.

MOHAVE QUADRANGLE.

Milepost 359, 5 feet from, 20 feet west of track; iron post stamped "3732 B"-----	3,734.298
Tehachapi, in front of station; top of rail-----	3,969.4
Tehachapi, at station, 30 feet north of track, 15 feet east of highway; iron post stamped "3966 B"-----	3,969.255
Tehachapi, summit; top of rail-----	4,030.0
Milepost 365, 12 feet south of, on west side of track, at margin of highway; iron post stamped "3995 B"-----	3,997.981
Milepost 368, opposite, on east side of track, at margin of highway; iron post stamped "3920 B"-----	3,922.709
Cameron, in front of station; top of rail-----	3,792.0
Cameron, 150 feet south of station, on west side of track, at margin of fence; iron post stamped "3790 B"-----	3,792.997

	Feet.
Milepost 374, opposite, 80 feet east of track; iron post stamped "3586 B"-----	3, 588. 914
Mohave, 4.7 miles north of, west side of track, 40 feet from milepost 377; iron post stamped "3272 B 1902"-----	3, 273. 919
Mohave, 2.7 miles north of, 70 feet north of milepost 379, on west side of railroad; iron post stamped "3030 B 1902"-----	3, 032. 494

MOHAVE, ALONG SOUTHERN PACIFIC RAILWAY, TO PACOIMA.

MOHAVE QUADRANGLE.

Mohave, in front of station; top of rail-----	2,757. 0
Mohave, 0.4 mile south of, 25 feet north of milepost 382, on west side of railroad; iron post stamped "2732 B 1902"-----	2, 733. 451

PALMDALE QUADRANGLE.

Rosamond, 10.4 miles north of, 12 feet south of milepost 385, on west side of railroad; iron post stamped "2639 B 1902"-----	2, 641. 311
Rosamond, 7.4 miles north of, 15 feet south of milepost 388, on east side of track; iron post stamped "2561 B 1902"-----	2, 562. 911
Rosamond, 4.4 miles north of, 10 feet south of milepost 391, on west side of track; iron post stamped "2543 B 1902"-----	2, 544. 409
Rosamond, 1.4 miles north of, 10 feet south of milepost 394, on west side of track; iron post stamped "2407 B 1902"-----	2, 408. 948
Rosamond, in front of station; top of rail-----	2, 328. 0
Lancaster, 9.6 miles north of, west of track, 12 feet south of milepost 397; iron post stamped "2311 B 1902"-----	2, 312. 885
Lancaster, 6.6 miles north of, 10 feet south of milepost 400, on west of track; iron post stamped "2302 B 1902"-----	2, 304. 022
Lancaster, 3.6 miles north of, at milepost 403, west side of track; iron post stamped "2302 B 1902"-----	2, 303. 913
Lancaster, 0.6 mile north of, 10 feet south of milepost 406, west of track; iron post stamped "2335 B 1902"-----	2, 336. 389
Lancaster, in front of station; top of rail-----	2, 357. 0
Palmdale, 5.9 miles north of, 50 feet from track, opposite milepost 409, on east side of track; iron post stamped "2462 B 1902"-----	2, 463. 882
Palmdale, 2.9 miles north of, 10 feet north of milepost 412, on west side of track; iron post stamped "2592 B 1902"-----	2, 593. 314
Palmdale, 150 feet north of station, on east side of track, telegraph pole; iron post stamped "2657 B 1902"-----	2, 658. 623
Harold, 165 feet north of water tank, at north end of section house fence, on east side of track; iron post stamped "2824"-----	2, 826. 028

TUJUNGA QUADRANGLE.

Vincent, 500 feet north of station, 500 feet west of center line of T. 5 N., R. 12 W., in corner of jog in fence; iron post stamped "3219"-----	3, 219. 258
Acton, southwest corner of hotel, in brick wall; bronze tablet stamped "2700"-----	2, 700. 771
Ravenna, 58 feet east of station office door, 35 feet from gum tree, on east side of track; iron post stamped "2468"-----	2, 468. 188

FERNANDO QUADRANGLE.

	Feet.
Lang, between hotel building and section house, 45 feet north of center of track; iron post stamped "1690"-----	1, 689. 544

SANTA SUSANA QUADRANGLE.

Saugus (Surrey post-office), 18 feet from north corner of pump house, 18 feet from center of track, 33 feet from south corner of station building; iron post stamped "1171"-----	1, 170. 641
Newhall, 27 feet south of station, 30 feet from center of track, between tree and telegraph pole; iron post stamped "1273"-----	1, 272. 195
Fernando tunnel, 0.25 mile south of south end of, at end of yard at section house; iron post stamped "1417"-----	1, 416. 373

FERNANDO QUADRANGLE.

Fernando, Maclay & Maclay Company's building on Johnson street, in southeast corner of brick wall; bronze tablet stamped "1066"-----	1, 066. 665
Pacoima, 165 feet northwest of northwest corner of brick station building, at corner of fence; iron post stamped "1013"-----	1, 013. 230

CHICO, DAVISVILLE, KNIGHTS LANDING, MARYSVILLE, RED BLUFF, REDDING, SHASTA, TEHAMA, VINA, AND WOODLAND QUADRANGLES.

BUTTE, PLACER, SHASTA, SISKIYOU, SUTTER, TEHAMA, YOLO, AND YUBA COUNTIES.

The elevations in the following list are a portion of the results of a double-simultaneous precise-level line run in 1902-3 by Mr. C. H. Semper, levelman, from Benicia, Cal., north along Southern Pacific Railroad to Portland, Oreg.

As originally computed and corrected for rod error, in accord with previous rating, it made a closure of 0.420 foot low on the elevation brought from Astoria to Portland by J. H. Carlock in 1898, but recent rerunning near Mohave over a precise line on which the same rods were used as on this line, on portion from Benicia to near Shasta Springs (where new rods were substituted at 2,650-foot elevation), showed an additional rod correction necessary to be applied of 0.0006 foot per vertical foot, increasing differences, and this would increase the elevation for Shasta Springs 1.59 feet, making a closure of 1.17 high at Portland. As a matter of adjustment the previous adjusted elevations by this line from Benicia to near Kennett were retained, the correction at Kennett being +0.13 at 680-foot elevation, and rod corrections applied thence to Shasta Springs make the correction to near Shasta Springs +1.3 feet, leaving 0.88 foot error, which has been adjusted between the latter place and Portland, a distance of 440 miles, at the rate of 0.002 foot per mile. A Buff & Berger precise level and two double-faced 10-foot nonextensible target rods were used.

Elevations in Oregon are not included, and elevations between Benicia and Davisville, Cal., are given in other lists, pages 13-14.

DAVIS, NORTH TO WOODLAND.

DAVISVILLE QUADRANGLE.

	Feet.
Davis, 0.4 mile east of, on south side of railroad, 5 feet from milepost 77; iron post stamped "42 B 1902"-----	42.095

WOODLAND QUADRANGLE.

Davis, 3.2 miles north of, on east side of railroad, 30 feet north of milepost 80; iron post stamped "48 B 1902"-----	48.400
Davis, 6.1 miles north of, on east side of railroad, 300 feet north of milepost 83, at railroad crossing; iron post stamped "53 B 1902"---	53.315
Woodland, at southeast corner of railroad park at station, 5 feet north of water tank; iron post stamped "60 B 1902"-----	60.260
Woodland, near station, at railroad crossing; top of rail-----	60.8

WOODLAND TO MARYSVILLE.

WOODLAND QUADRANGLE.

Woodland, 2.6 miles north of, on east side of railroad, at fence line, at milepost 89; iron post stamped "62 B 1902"-----	61.589
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KNIGHTS LANDING QUADRANGLE.

Woodland, 5.6 miles north of, on east side of railroad, at milepost 92, at fence line; iron post stamped "30 B 1902"-----	30.201
Knights Landing, in front of station; top of rail-----	36.7
Knights Landing, at railroad station, 30 feet east of track, at corner of highway and on line of north side of station; iron post stamped "32 B 1902"-----	31.825
Knights Landing, 5 miles north of, on west side of railroad, 6 feet from rail, opposite milepost 100; iron post stamped "37 B 1902"---	37.432
Knights Landing, 8.1 miles north of, on west side of railroad, 10 feet from tract, opposite milepost 103; iron post stamped "38 B 1902"---	38.006
Chandler, in front of station; top of rail-----	36.4
Marcuse, 0.4 mile north of, on west side of railroad at fence line, 5 feet north of milepost 109; iron post stamped "33 B 1902"-----	32.878
Tudor, 0.2 mile south of, on west side of railroad, at fence line, 5 feet north of milepost 112; iron post stamped "40 B 1902"-----	39.844

MARYSVILLE QUADRANGLE.

Tudor, in front of station; top of rail-----	39.9
Tudor, 2.8 miles north of, on west side of railroad, at fence line, 5 feet north of milepost 115; iron post stamped "43 B 1902"-----	43.431
Tudor, 5.8 miles north of, on west side of railroad, at fence line, 5 feet north of milepost 118; iron post stamped "53 B 1902"-----	53.073
Tudor, 8.8 miles north of, on west side of railroad, at fence line, 5 feet north of milepost 121; iron post stamped "58 B 1902"-----	57.712
Yuba City, in front of station; top of rail-----	57.5
Marysville, at railroad station, 225 feet west of track, at southeast corner of railroad park; iron post stamped "61 B 1902"-----	61.202

MARYSVILLE TO RED BLUFF.

MARYSVILLE QUADRANGLE.

	Feet.
Marysville, 2.8 miles north of, on east side of railroad, 300 feet north of long trestle, 10 feet east of track, opposite milepost 145; iron post stamped "72 B 1902"-----	71. 774
Marysville, 5.7 miles north of, on east side of railroad, 4 feet north of milepost 148, at fence line; iron post stamped "66 B 1902"-----	66. 420
Marysville, 8.7 miles north of, on east side of railroad, at fence line, 4 feet north of milepost 151; iron post stamped "73 B 1902"-----	73. 520
Live Oak, in front of station; top of rail-----	75. 8
Live Oak, 2 miles north of, on east side of railroad, 5 feet north of milepost 155; iron post stamped "82 B 1902"-----	81. 873
Live Oak, 5 miles north of, on east side of railroad, at road crossing, 30 feet south of milepost 158; iron post stamped "92 B 1902"-----	92. 520
Gridley, in front of station; top of rail-----	92. 7
Gridley, 1.7 miles north of, on east side of railroad, 480 feet north of milepost 161, at fence line; iron post stamped "90 B 1902"-----	90. 191
Biggs, in front of station; top of rail-----	93. 7
Biggs, 1.3 miles north of, on west side of railroad, 900 feet north of milepost 164, 50 feet west of track, at telegraph pole; iron post stamped "91"-----	90. 789
Biggs, 4.2 miles north of, on east side of railroad, 5 feet north of milepost 167; iron post stamped "99 B 1902"-----	98. 900

CHICO QUADRANGLE.

Biggs, 7.1 miles north of, on east side of railroad, 5 feet north of milepost 170; iron post stamped "107 B 1902"-----	107. 543
Nelson, in front of station; top of rail-----	121. 0
Nelson, 700 feet north of station, on east side of railroad, 5 feet north of milepost 173; iron post stamped "120 B 1902"-----	119. 767
Nelson, 3.1 miles north of, on east side of railroad, 4 feet north of milepost 176; iron post stamped "128 B 1902"-----	128. 010
Durham, 0.4 mile south of, on east side of railroad, 270 feet north of milepost 179, 5 feet from telephone pole; iron post stamped "152 B 1902"-----	152. 298
Durham, in front of station; top of rail-----	159. 1
Durham, 2.5 miles north of, on east side of railroad, 5 feet north of milepost 182; iron post stamped "182 B 1902"-----	181. 879
Chico, 0.5 mile south of, on east side of railroad, 5 feet north of milepost 185; iron post stamped "185 B 1902"-----	184. 842
Chico, in front of station; top of rail-----	188. 7
Chico, State Normal School, southwest corner of building, front face; aluminum tablet stamped "201 B 1902"-----	200. 776
Chico, 3.4 miles north of, on east side of railroad, 5 feet north of milepost 189; iron post stamped "156 B 1902"-----	155. 696
Chico, 6.4 miles north of, on east side of railroad, 5 feet north of milepost 192; iron post stamped "145 B 1902"-----	144. 810
Nord, in front of station; top of rail-----	148. 4
Nord, 2.3 miles north of, on east side of railroad, 5 feet north of milepost 195; iron post stamped "156 B 1902"-----	156. 086

PRECISE LEVELING.

25

VINA QUADRANGLE.

	Feet.
Cana, in front of station; top of rail-----	168. 1
Cana, 0.7 mile north of, on east side of railroad, 3 feet north of milepost 198; iron post stamped "169 B 1902"-----	169. 142
Cana, 3.6 miles north of, east side of railroad, 3 feet north of milepost 201; iron post stamped "179 B 1902"-----	179. 088
Vina, 0.4 mile south of, on east side of railroad, 3 feet north of milepost 204; iron post stamped "202 B 1902"-----	202. 206
Vina, in front of station; top of rail-----	206. 4
Vina, 2.6 miles north of, on east side of railroad, 225 feet north of milepost 207, 12 feet from fence; iron post stamped "201 B 1902"---	201. 514

TEHAMA QUADRANGLE (RED BLUFF 1° QUADRANGLE).

Vina, 5.5 miles north of, on east side of railroad, 4 feet north of milepost 210; iron post stamped "210 B 1902"-----	210. 571
Tehama, 450 feet south of station, 4 feet north of milepost 213, on east side of railroad; iron post stamped "213 B 1902"-----	213. 107
Tehama, in front of station; top of rail-----	217. 5
Tehama, 3 miles north of, on east side of railroad, 3 feet north of milepost 216; iron post stamped "237 B 1902"-----	237. 512
Proberta, in front of station; top of rail at crossing-----	252. 5
Proberta, 1.7 miles north of, on east side of railroad, 3 feet north of milepost 219; iron post stamped "266 B 1902"-----	266. 035
Proberta, 4.7 miles north of station, on east side of railroad, 3 feet north of milepost 222; iron post stamped "291 B 1902"-----	289. 889

RED BLUFF TO DUNSMUIR.

TEHAMA QUADRANGLE (RED BLUFF 1° QUADRANGLE).

Red Bluff, in front of station; top of rail-----	303. 6
Red Bluff, at Crittington-street crossing, on north margin of road, 50 feet east of track, at milepost 225; iron post stamped "309 B 1902"-----	308. 797

RED BLUFF 1° QUADRANGLE.

Red Bluff, 3.1 miles north of, on east side of railroad, 300 feet north of milepost 228, 15 feet from fence; iron post stamped "370 B 1902"-----	369. 720
Red Bluff, 6 miles north of, on east side of railroad, 100 feet south of milepost 231, at telegraph pole; iron post stamped "437 B 1902"-----	437. 073
Red Bluff, 9 miles north of, on east side of railroad, 400 feet north of milepost 234, at fence line; iron post stamped "591 B 1902"-----	591. 014
Hooker, in front of station; top of rail-----	538. 9
Hooker, 1.8 miles north of, 110 feet north of milepost 237, 30 feet west of track, at telegraph pole; iron post stamped "491 B 1902"-----	491. 195
Hooker, 4.7 miles north of, on east side of railroad, 3 feet north of milepost 240; iron post stamped "433 B 1902"-----	433. 244
Cottonwood, in front of station; top of rail-----	477. 5

	Feet.
Cottonwood, 1 mile north of, on east side of railroad, 150 feet north of milepost 243, at telegraph pole; iron post stamped "421 B 1902"---	421. 134
Cottonwood, 5 miles north of, on east side of railroad, 3 feet north of milepost 247; iron post stamped "464 B 1902"-----	464. 464
Anderson, in front of station; top of rail-----	428. 0
Anderson, 1.3 miles north of, on east side of railroad, 150 feet south of milepost 250, at telegraph pole; iron post stamped "434 B 1902"-----	434. 277
Anderson, 4.3 miles north of, on east side of railroad, 300 feet north of milepost 253, at telegraph pole; iron post stamped "470 B 1902"-----	470. 128

REDDING QUADRANGLE (RED BLUFF 1° QUADRANGLE).

Anderson, 7.2 miles north of, on east side of railroad, 3 feet north of milepost 256; iron post stamped "474 B 1902"-----	474. 066
Redding, 0.7 mile south of, on east side of railroad, 4 feet south of milepost 259; iron post stamped "532 B 1902"-----	531. 804
Redding court-house, first angle of wall on north side of east entrance; aluminum tablet stamped "590 B 1902"-----	589. 658
Middle Creek, in front of station; top of rail-----	521. 8
Middle Creek (Waugh post-office), 600 feet north of station, 15 feet west of track, at telegraph pole opposite hotel; iron post stamped "521 B 1902"-----	521. 299
Keswick, in front of station; top of rail-----	562. 9
Keswick, 0.6 mile north of, 100 feet north of milepost 266, 12 feet east of railroad telegraph pole; iron post stamped "569 B 1902"-----	569. 310
Copley, 5 feet south of southwest corner of schoolhouse (Flat Creek district); iron post stamped "729 B 1902"-----	729. 476
Copley, at freight house; top of upper rail-----	595. 4
Copley, 3.4 miles north of, 15 feet south of railroad, 150 feet west of milepost 273; iron post stamped "628 B 1902"-----	627. 714
Kennett, 1.3 miles west of, on east side of railroad, 100 feet south of milepost 276, at telegraph pole; iron post stamped "654 B 1902"---	654. 141
Kennett, in front of station; top of rail-----	665. 3
Kennett, 1.8 miles north of, on east side of railroad, 300 feet north of milepost 279, at telegraph pole; iron post stamped "679 B 1902"---	678. 728
Kennett, 4.8 miles north of, on east side of railroad, 300 feet north of milepost 282, at telegraph pole; iron post stamped "722 B 1902"---	722. 492
Elmore, 3 feet west of fence west of Schoonover's house, 900 feet east of center of railroad trestle over Sacramento River, 58 feet south of tracks; iron post stamped "789 B 1902"-----	788. 741
Elmore, in front of station sign; top of rail-----	795. 8
Elmore, 3.7 miles north of, on east side of railroad, 5 feet from milepost 289; iron post stamped "901 B 1902"-----	901. 600
Baird (Gregory post-office), railroad crossing at station; top of rail---	962. 3
Baird, 12 feet south of southeast corner of Smithson schoolhouse; iron post stamped "1022 B 1902"-----	1, 022. 643
Baird, 2.9 miles north of, on east side of railroad, 300 feet north of milepost 295, at telegraph pole; iron post stamped "1034 B 1902"---	1, 034. 630
Delta, in front of station; top of rail-----	1, 133. 6

	Feet.
Delta, in front of schoolhouse, 3 feet north of center of porch, 100 feet south of Oregon road; iron post stamped "1319 B 1902"-----	1, 319. 608
Lamoine, 600 feet south of store, 20 feet south of bridge over stream, on east side of railroad, at telegraph pole; iron post stamped "1236 B 1902"-----	1, 236. 822
Lamoine, 2.1 miles north of, on east side of railroad, 8 feet north of milepost 304; iron post stamped "1320 B 1902"-----	1, 320. 737

SHASTA 1° QUADRANGLE.

Lamoine, 4.9 miles north of, on east side of railroad, 300 feet south of bridge No. 8 over Sacramento River, 10 feet north of telegraph pole; iron post stamped "1449 B 1902"-----	1, 449. 906
Sims, 1 mile south of, on east side of railroad, 300 feet south of milepost 310, at telegraph pole; iron post stamped "1607 B 1902"-----	1, 608. 010
Sims, in front of station; top of rail-----	1, 669. 9
Sims, 2 miles north of, on east side of railroad, 540 feet north of milepost 313, at telegraph pole; iron post stamped "1779 B 1902"-----	1, 780. 082
Sims, 5 miles north of, on east side of railroad, 300 feet north of milepost 316, at telegraph pole; iron post stamped "1900 B 1902"-----	1, 900. 900
Castella, in front of station; top of rail-----	1, 943. 6
Castella, 2.1 miles north of, on east side of railroad, 7 feet north of milepost 319; iron post stamped "2056 B 1902"-----	2, 057. 044
Castle Crag, in front of station; top of rail-----	2, 091. 8
Castle Crag, 2.1 miles north of, on east side of railroad, 150 feet north of milepost 322, 7 feet from telegraph pole; iron post stamped "2186 B 1902"-----	2, 187. 316
Dunsmuir, in front of station; top of rail-----	2, 284. 1

DUNSMUIR TO OREGON STATE LINE.

SHASTA 1° QUADRANGLE.

Dunsmuir, 1 mile north of, at upper Soda Springs flag station, 10 feet east of railroad, at corner of station; iron post stamped "2355 B 1902"-----	2, 356. 559
Shasta Springs, in front of station; top of rail-----	2, 539. 1
Shasta Springs, 1.1 miles north of, on east side of railroad, 5 feet from milepost 331; iron post stamped "2650 B 1902"-----	2, 651. 671
Shasta Springs, 4.1 miles north of, on east side of railroad, 5 feet from milepost 331; iron post stamped "2942 B 1902"-----	2, 943. 629
Mott, 35 feet south of station, on east side of railroad, 3 feet south of milepost 333; iron post stamped "3154 B 1902"-----	3, 154. 768
Mott, in front of station; top of rail-----	3, 154. 1
Mott, 2.8 miles north of, on east side of railroad, 4 feet north of fourth telegraph pole south of milepost 336; iron post stamped "3392 B 1902"-----	3, 393. 326
Sisson, in front of station; top of rail-----	3, 553. 0
Sisson, 0.6 mile north of, on east side of railroad, 150 feet north of milepost 339, 4 feet from telegraph pole; iron post stamped "3596 B 1902"-----	3, 597. 008
Upton, in front of station; top of rail-----	3, 703. 9

	Feet.
Upton, 2.3 miles north of, on east side of railroad, 8 feet from mile-post 343; iron post stamped "3791 B 1902"-----	3, 792. 039
Upton, 5.4 miles north of, on east side of railroad, 10 feet from mile-post 346; iron post stamped "3879 B 1902"-----	3, 879. 906
Igerna, in front of station; top of rail-----	3, 732. 7
Igerna, 1.6 miles north of, on west side of railroad, opposite milepost 349, 5 feet from telegraph pole; iron post stamped "3568 B 1902"-----	3, 568. 712
Weed, 1.9 miles north of, on east side of railroad, 2 feet from mile-post 352; iron post stamped "3255 B 1902"-----	3, 256. 716
Edgewood, 600 feet south of station, on east side of railroad, at mile-post 355; iron post stamped "2957 B 1902"-----	2, 958. 389
Edgewood, in front of station; top of rail-----	2, 950. 0
Edgewood, 2.8 miles north of, on east side of railroad, 5 feet north of milepost 358; iron post stamped "2909 B 1902"-----	2, 910. 178
Edgewood, 5.8 miles north of, on east side of railroad, 2 feet from milepost 361; iron post stamped "2824 B 1902"-----	2, 825. 403
Gazelle, in front of station; top of rail-----	2, 756. 8
Gazelle, 1.3 miles north of, on east side of railroad, 3 feet from mile-post 364; iron post stamped "2717 B 1902"-----	2, 718. 258
Gazelle, 4.3 miles north of, on east side of railroad, at milepost 367; iron post stamped "2625 B 1902"-----	2, 626. 212
Gazelle, 7.2 miles north of, on east side of railroad, at milepost 370; iron post stamped "2554 B 1902"-----	2, 555. 433
Gazelle, 10.3 miles north of, on east side of railroad, at milepost 373; iron post stamped "2524 B 1902"-----	2, 525. 110
Montague, 1 mile south of, on east side of railroad, second telegraph pole north of milepost 376; iron post stamped "2518 B 1902"-----	2, 518. 845
Montague, in front of station; top of rail-----	2, 538. 4
Montague, 1.8 miles north of, on east side of railroad, at milepost 379; iron post stamped "2563 B 1902"-----	2, 563. 776
Montague, 4.8 miles north of, on east side of railroad, at first telegraph pole north of milepost 382; iron post stamped "2658 B 1902"-----	2, 658. 892
Montague, 7.7 miles north of, on east side of railroad, at first telegraph pole south of milepost 385; iron post stamped "2544 B 1903"-----	2, 544. 622
Ager, in front of station; top of rail-----	2, 330. 9
Ager, 800 feet north of station, on east side of railroad, at milepost 388; iron post stamped "2322 B 1903"-----	2, 323. 609
Ager, 3 miles north of, on west side of railroad, at milepost 391; iron post stamped "2115 B 1903"-----	2, 115. 804
Hornbrook, 0.8 mile south of, on west side of railroad, 200 feet south of milepost 394, at fence line; iron post stamped "2114 B 1903"-----	2, 115. 298
Hornbrook, in front of station; top of rail-----	2, 151. 7
Hornbrook, 2.2 miles north of, on east side of railroad, 30 feet north of milepost 397, at fence line; iron post stamped "2306 B 1903"-----	2, 306. 975
Hornbrook, 5.1 miles north of, on west side of railroad, 240 feet south of milepost 400, at telegraph pole; iron post stamped "2786 B 1903"-----	2, 786. 767
Hornbrook, 8.2 miles north of, on west side of railroad, at telegraph pole, opposite milepost 403; iron post stamped "2897 B 1903"-----	2, 898. 176
Cole, in front of station; top of rail-----	2, 862. 8

PRIMARY LEVELING.

ELSINORE, FLOWING WELL, INDIO SPECIAL, REDLANDS, SALTON, SAN BERNARDINO, SAN JACINTO,
AND YUMA QUADRANGLES.

RIVERSIDE, SAN BERNARDINO, AND SAN DIEGO COUNTIES.

The purpose of this double primary line was to establish bench marks at Yuma and to determine their elevations above mean sea level by direct connection with tidal gage.

The following elevations are the result of primary leveling by Mr. R. A. Farmer, October, 1902, to January, 1903, beginning at Colton at a bronze tablet stamped "978," set horizontally in brick wall over corner pier of the Transcontinental Hotel. The elevation originally accepted for this bench mark was determined by a double-rodged primary line run from San Pedro to San Bernardino, published in the Appendix to the Nineteenth Annual Report, but the value then given is now considered to be 0.7 foot too small. The elevation of this bench mark is now accepted as 979.073 feet above mean sea level as derived by connection at San Bernardino with the above line by precise leveling of 1906 of the United States Coast and Geodetic Survey from a more reliable tidal record at Point Loma near San Diego.

The portion of this line from Colton to Montmere is a single rerunning of a line previously run, as published in Appendix to the Nineteenth Annual Report, a second rerunning being made when local divergences were excessive.

From Montmere to Yuma the line, as it progressed, was checked by running forward a certain distance and then back over the same section. If there was a discrepancy in feet of more than $0.05 \sqrt{\text{circuit mileage}}$ between the two determinations the section was rerun a third time or more, until satisfactory results were obtained. At Yuma checks were obtained with the levels of the International boundary, as well as those of the Southern Pacific Company, the United States Geological Survey elevation being 0.2 foot lower than that obtained from the Southern Pacific Company, corrected to mean sea level for the bridge seat of the bridge across the Colorado River, and 0.18 foot lower than that obtained from the International Boundary Report by connection with monument No. 207 of the International boundary line.

COLTON, ALONG SOUTHERN PACIFIC RAILROAD, TO YUMA, ARIZ.

SAN BERNARDINO QUADRANGLE.

	Feet.
Colton, in front wall of Transcontinental Hotel; bronze tablet stamped "978 S B"-----	979.073
Mound City, reservoir east of depot, northeast corner of wall; copper bolt stamped "1079 S B"-----	1,079.762

REDLANDS QUADRANGLE.

	Feet.
Redlands Junction, east of station, west side of county road, and south line of Southern Pacific Company's right of way; iron post stamped "1201 S B"-----	1, 201. 693
Brookside, west of siding, west side of county road, at southeast corner of Brookside vineyard; iron post stamped "1301 S B"-----	1, 301. 906

ELSINORE QUADRANGLE.

San Timoteo district school, northwest corner of grounds; iron post stamped "1910 S B"-----	1, 911. 237
T. 3 S., between Rs. 2 and 1 W., north side of county road; iron post stamped "2297 S B"-----	2, 297. 835

SAN JACINTO QUADRANGLE.

Beaumont, Gray's brick store and warehouse, in the front wall at northwest corner; bronze tablet stamped "2575 S B"-----	2, 575. 909
Banning, opposite Hotel Banning, in east wall of Frayer brick block; bronze tablet stamped "2330 S B"-----	2, 330. 516
Cabazon, 7 feet east of southeast corner of section house, grounds north of track, in corner of stone-bordered walk; iron post stamped "1791 S B"-----	1, 791. 579
T. 3 S., between Rs. 2 and 3 E., east of road crossing on north side of Southern Pacific Company's right of way; iron post stamped "1442 S B"-----	1, 442. 584
Whitewater Siding, south of track, at northeast corner of section house grounds; iron post stamped "1130 S B"-----	1, 130. 633
Palm Springs, 170 feet east of station, at east end of row of palm trees, 13 feet south of track; iron post stamped "685 T"-----	686. 055
Palm Springs, 3.5 miles southeast of, 45 feet west of track, 4 feet northwest of milepost 592; iron post stamped "539 T"-----	540. 053

INDIO SPECIAL QUADRANGLE.

Rimlon, 0.16 mile southeast of signboard at section house, 45 feet southwest of track, near milepost 596; iron post stamped "342 T"-----	342. 910
Dry Camp, 45 feet southwest of track, 90 feet west of switch at northwest end of siding; iron post stamped "164 T"-----	164. 730
Myoma Siding, 100 feet west of, at west end of switch, 45 feet southwest of track; iron post stamped "70 T"-----	70. 761
Indio, in southeast corner of schoolhouse yard; iron post stamped "15 T" (below mean sea level)-----	— 14. 145
Woodspur, 50 feet southwest of track, at road crossing; iron post stamped "—66 T"-----	— 65. 344
Thermal, 300 feet northwest of signboard, 45 feet southwest of track, 5 feet northwest of telegraph pole; iron post stamped "—121 T"-----	—120. 087
Walters, 27 feet northwest of station, in corner of yard; iron post stamped "—189 T"-----	—188. 341
Montmore, 100 feet southeast of, switch stand at west end of siding, 45 feet south of track, 4 feet south of wagon road, 4 feet west of telegraph pole; iron post stamped "—248 T"-----	—247. 280

SALTON QUADRANGLE.

	Feet.
Salton, 50 feet north of post-office, 150 feet south of station, on railroad right of way line; iron post stamped "—257 SB"-----	—256.537
Durmid, in northeast corner of section-house ground; iron post stamped "—248 S B"-----	—247.060
Bertram, 50 feet south of railroad, 10 feet east of northeast corner of station; iron post stamped "—249 SB"-----	—247.796
Frink, 50 feet south of station, 6 feet east of milepost; iron post stamped "—258 SB"-----	—257.703
Volcano, in northeast corner of section-house grounds; iron post stamped "—221 S B"-----	—220.039
Old Beach, at west end of switch, 8 feet east of milepost 666; iron post stamped "—124 SB"-----	—122.899

FLOWING WELL QUADRANGLE.

Iris, 5 telegraph poles east of, 4 feet west of milepost 673; iron post stamped "77 SB" (above mean sea level)-----	77.257
Tortuga, 100 feet west of signboard, 4 feet east of milepost 677; iron post stamped "186 S B"-----	186.930
Milepost 680, 1,100 feet east of, 20 feet north of warning board at crossing; iron post stamped "220 SB"-----	220.800
Mammoth, 400 feet west of station, 50 feet south of railroad track; iron post stamped "259 S B"-----	259.610
Acolita, 50 feet south of track, 10 feet east of milepost 689; iron post stamped "271 S B"-----	271.376
Mesquite, 400 feet east of signboard at milepost 694; iron post stamped "295 S B"-----	295.249
Glamis, 1,800 feet east of station, 8 feet east of milepost 697; iron post stamped "338 S B"-----	338.690
Ruthven, 3 miles east of, east end of switch, 9 feet east of milepost 702; iron post stamped "379 S B"-----	379.380

YUMA QUADRANGLE.

Drylyn, 200 feet east of signboard, 8 feet east of milepost 708; iron post stamped "397 S B"-----	397.998
Cactus, 1,200 feet east of milepost 713, 4 feet west of signboard; iron post stamped "367 S B"-----	368.107
Ogilby, 300 feet west of section house, 6 feet east of milepost 715; iron post stamped "356 S B"-----	356.388
Knob, 200 feet west of station house; iron post stamped "294 SB"-----	294.741
Araz, 4 feet west of signboard; iron post stamped "156 S B"-----	157.126
Yuma, top of pier, north side of bridge over Colorado River; aluminum tablet stamped "137 S B"-----	138.100
Yuma, in front of passenger station; top of north rail-----	142.78-

BLAISDELL, CAMP MOHAVE, EHRENBURG SPECIAL, NEEDLES SPECIAL, PARKER, PICACHO, AND YUMA QUADRANGLES.

RIVERSIDE, SAN BERNARDINO, AND SAN DIEGO COUNTIES.

The elevations in the following list are based upon a double primary-level line from San Bernardino to Yuma, based upon the United States Coast and Geodetic Survey precise-level line of 1906 from mean sea level at San Diego.

The leveling on Yuma quadrangle was done in 1902-3 under the direction of Mr. R. B. Marshall, topographer, by Messrs. C. J. Hoover, G. L. Gordon, and L. D. Ryus, levelmen; that on Picacho and Ehrenberg quadrangles was done in 1903 partly under Mr. Hersey Munroe, topographer, by E. W. Glafcke, levelman, and partly under Mr. Marshall by G. L. Gordon and L. D. Ryus; that on Parker quadrangle was done under Mr. Munroe partly in 1902-3 by Mr. Glafcke and partly in 1903 by Mr. S. E. Blout. That on Needles quadrangle was done partly in 1902 under Mr. E. C. Barnard, topographer, by Mr. H. Morrison, and partly in 1902-3 under Mr. Munroe by Messrs. Glafcke and Blout.

The leveling on Camp Mohave quadrangle was done in 1902 under Mr. Barnard by Mr. Morrison and that on quadrangle next to Parker in 1903 under Mr. Munroe by Mr. Blout.

YUMA QUADRANGLE.

YUMA, NORTHEAST ALONG WAGON ROAD, TO POTHOLES.

	Feet.
Yuma, 12.72 miles northeast of, 10 feet west of Yuma and Potholes road, north side of point of hill, south side of Pothole Canyon; iron post stamped "148 Y"-----	149.051

YUMA, NORTH ALONG ROAD, VIA MAGGIES WELL, TO PICACHO.

Maggies Well, T. 16 S., R. 22 E., southwest corner of section 1; iron post stamped "139 Y"-----	139.669
T. 15 S., R. 22 E., section 15, west side of road; iron post stamped "445 Y"-----	445.267
T. 14 S., R. 22 E., section 27, at intersection of stage road and small loop of road; iron post stamped "767 Y"-----	767.824
Picacho mine, 1.2 miles north of, on west side of road; iron post stamped "574 Y"-----	574.185

PICACHO, WEST ALONG PICACHO-YUMA ROAD, VIA AMERICAN MINE, TO OGILBY.

T. 15 S., R. 21 E., near southeast corner section 1, on north side of road; iron post stamped "635 Y"-----	636.051
American mine, 0.6 mile east of, on north side of road; iron post stamped "699 Y"-----	700.313

PRIMARY LEVELING.

33

OGILBY, SOUTHWEST TO SAND HILLS (SINGLE SPUR LINE).

T. 16 S., R. 20 E., north side section 29, 5 miles southwest of Ogilby; iron post stamped "174 Y"-----	Feet. 174.682
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POINT 2 MILES NORTHEAST OF OGILBY, NORTH VIA HEDGE'S MINE 10 MILES (SINGLE SPUR LINE).

T. 14 S., R. 20 E., section 23, 4.3 miles north of Hedge's mine, 9.9 miles north of Ogilby; iron post stamped "697 Y"-----	698.233
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ARAZ, SOUTHWEST TO MEXICAN BOUNDARY.

Monument No. 207; base of masonry ^a -----	155.96
Monument No. 207, on United States side; iron post stamped "155 Y"-----	156.024
Monument No. 206; base of masonry-----	119.37
Monument No. 206, in foundation, United States side; top of bolt----	119.676

BLAISDELL QUADRANGLE.

POTHOLE, NORTH TO CASTLE DOME LANDING.

Castle Dome landing, 0.25 mile west of river, east side of road, at foot of hill; iron post stamped "165 Y"-----	165.943
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PICACHO QUADRANGLE.

CASTLE DOME LANDING, NORTHWEST TO PICACHO.

Ferguson's old pumping plant, south side of hill at foot of bluff, 100 feet west of river bank; iron post stamped "177 Y"-----	177.239
Picacho cyanide plant, 1 mile northwest of, 0.5 mile north of school- house, at point of hill west of road; iron post stamped "187 Y"----	187.321

PICACHO, NORTHWARD ALONG WEST SIDE OF COLORADO RIVER, TO COMER'S RANCH.

Picacho, 8 miles north of, 33.90 miles south of Hodge's ranch, 20 feet east from road, in small saddle, 650 feet west of river, at upper end of large flat; iron post stamped "213 Y"-----	213.253
Hodge's ranch, 23.7 miles south of, 600 feet west of river, 150 feet east of cliffs, 50 feet west of road, north end of clearing in open flat; iron post stamped "208 Y"-----	208.919
Hodge's ranch, 18.5 miles south of, 30 feet west of road, on point of mesa 250 feet west of river; iron post stamped "224 Y"-----	224.388
Hodge's ranch, 14.68 miles south of, 10 feet west of forks of road, 500 feet southwest of old pumping station, at 4 tanks formerly used by Praymaster mine; iron post stamped "229 Y"-----	229.761
Hodge's ranch, 11.2 miles south of, 10 feet west of road, 750 feet north of Sobrino ranch, 200 feet due west of brush hut and corral; iron post stamped "232 Y"-----	232.536
Hodge's ranch, 3.5 miles southeast of, 25 feet east of road to Picacho, in small clearing in flat, 0.5 mile west of lagoon, 1 mile west of river; iron post stamped "227 Y"-----	227.374

^a Elevation by United States and Mexican Boundary Commission, 156.14 feet.

	Feet.
Hodge's ranch, 100 feet west of house, 200 feet west of lagoon, 300 feet south of county line between Santiago and Riverside counties, 15 feet west of road, in flat 19.7 miles southwest of Ehrenberg, Ariz.; iron post stamped "232 Y"-----	232. 196
Ehrenberg, 13.8 miles southwest of, 1.54 miles south of Comer's ranch, at forks of road in open flat; iron post stamped "241 Y"-----	241. 633

POINT 10 MILES NORTH OF PICACHO, ALONG ROAD MAKING CIRCUIT WEST, NORTH, AND EAST, TO POINT 12 MILES SOUTH OF HODGE'S RANCH.

Colorado River, 5.42 miles west of, half way between two triangulation signals on points in range of hills, on summit of divide at head of canyon; iron post stamped "1045 Y"-----	1045. 954
Summit of divide, 5 miles north of, 6 miles west of river at forks of two large washes, in view of three triangulation signal points on west side of river and of one on east side of river; iron post stamped "713 Y"-----	713. 650
Eagle oil well, 0.75 mile west of, 20 feet south of Ogilby and Palo Verde stage road; iron post stamped "561 Y"-----	561. 750

POINT 2.5 MILES SOUTH OF HODGE'S RANCH, ALONG ROAD WEST AND NORTH, TO SALTON-EHRENBERG ROAD.

Palo Verde post-office, 6.24 miles west of, on black rock mesa, 2 miles east of Spring Peak; iron post stamped "583 Y"-----	583. 887
Hodge's mine, 0.5 mile south of, 80 feet north of Salton-Ehrenberg road, 1 mile east of triangulation signal on point of mesa; iron post stamped "444 Y"-----	444. 985

EHRENBERG SPECIAL QUADRANGLE.

COMER'S RANCH, NORTH ALONG ROAD ON WEST SIDE OF RIVER, TO EHRENBERG, ARIZ.

Ehrenberg, 8.5 miles southwest of, 1 miles west of river, 30 feet west of road, at site of old abandoned ranch; iron post stamped "253 Y"-----	252. 733
Ehrenberg, 4.5 miles southwest of, 1.5 miles west of river, 15 feet west of road, in valley of Blythe estate, 600 feet north of wash; iron post stamped "258 Y"-----	258. 395
Parker, 48 miles southwest of, 0.5 mile north of ranch house at forks of road, opposite and west of landing at Ehrenberg, 0.75 mile in open flat, 30 feet west of road; iron post stamped "269 Y"-----	270. 338

OPPOSITE EHRENBERG, ARIZ., NORTH ALONG WEST SIDE OF RIVER, TO LA CRESENTA MINING COMPANY'S HOUSE.

Parker, 41 miles southwest of, 0.35 mile west of river, between forks of road to Blythe ranch and Ehrenberg, in open flat; iron post stamped "285 Y"-----	286. 283
Parker, 36 miles southwest of, at east end of Santa Maria Mountains, 300 feet west of river, north end of Blythe estate, in limestone; bronze tablet stamped "299 Y"-----	299. 933
Parker, 32.1 miles southwest of, 0.25 mile west of river, south side of road wash, on east edge of bare mesa, in large boulder; bronze tablet stamped "334 Y"-----	334. 817

PRIMARY LEVELING.

35

	Feet.
Parker, 28 miles southwest of, 1.25 miles west of river, 1 mile northwest of cabin foot of mesa, edge of flat, in large boulder; bronze tablet stamped "393 Y"-----	393. 852
Parker, 23.2 miles southwest of, 500 feet west of river, at southeast end of Riverside range of mountains, in ledge of limestone, point of rocks; bronze tablet stamped "360 Y"-----	361. 093
Parker, 18.2 miles southwest of, 40 feet east of northwest corner of adobe house of the La Cresenta Mining Company; bronze tablet stamped "364 Y"-----	364. 320

NORTH ALONG SALTON-EHRENBERG ROAD, VIA BLYTHE TRIANGULATION STATION, TO POINT
8 MILES NORTH OF EHRENBERG.

Salton road, 5.98 miles north of, 3 miles west of Willow Springs, on edge of second bench of mesa; iron post stamped "384 Y"-----	384. 547
Blythe triangulation station, 1 mile west of Mesquite Flat, at point of mesa; iron post stamped "390 Y"-----	391. 035
Blythe ranch, 1 mile west of, 600 feet east of mesa, 20 feet east of Palo Verde, 10 feet south of road; iron post stamped "297 Y"---	297. 776

PARKER QUADRANGLE.

NORTHEAST ALONG ROAD TO OPPOSITE BILL WILLIAMS FORK, THENCE NORTHWEST ALONG
ROAD TO LIVERPOOL LANDING.

Parker, 13.5 miles southwest of, top of mesa 0.5 mile west of river landing of Right & Lawrence Mining Company, 1.5 miles east of Riverside Mountain, in large boulder set in ground; bronze tablet stamped "405 Y"-----	405. 380
Parker, 8 miles southwest of, 0.25 mile west of river, opposite center of large island at head of big draw, on mesa; iron post stamped "415 Y"-----	415. 918
Parker, 3.5 miles west of, 600 feet west of river, top of mesa, 400 feet due west of triangulation point, on edge of same; iron post stamped "410 Y"-----	410. 731
Bill Williams Fork, 15.1 miles south of, 200 feet west of river, on east slope of mesa, 100 feet west of trail; iron post stamped "372 Y"---	372. 863
Bill Williams Fork, 10 miles south of, lower end of Empire Flats (California side of river), 700 feet west of river, 600 feet east of mesa in open flat; iron post stamped "370 Y"-----	370. 865
Bill Williams Fork, 4.6 miles south of, 800 feet west of big bend in river at point in cliffs, lower end of Empire Flats (California side), in saddle; iron post stamped "412 Y"-----	412. 458
Bill Williams Fork of the Colorado River, 1,200 feet due west of mouth of, 60 feet west of river, on west bank, on large mound of rock in ledge at foot of cliffs; bronze tablet stamped "400 Y"-----	401. 010
Pete McGuire, 300 feet north of (California side of river); iron post stamped "401 Y"-----	402. 308
Mellen, Ariz., 35 miles southeast of, 2.45 miles south of Tom Drennis stamp mill, 300 feet west of river, on east slope of mesa, in boulder; bronze tablet stamped "414 Y"-----	415. 330
Mellen, 30 miles southeast of, on west bank (California side) of river; bronze tablet stamped "417 Y"-----	417. 619
Chemehuevis Valley, lower end of, west bank of river, on point of mesa; iron post stamped "437 Y"-----	438. 036

LIVERPOOL LANDING, SOUTHWEST TO WEST WELL.

	Feet.
West Well, in Chemehuevis Valley, on east side of road to Parker, 50 feet north of pump; iron post stamped "762 Y"-----	762.309

POINT 11 MILES SOUTH OF WEST WELL, SOUTHEAST TO PARKER, ARIZ.

West Well, 11 miles south of, on west side of road, on summit of mountain; iron post stamped "1888 Y"-----	1,888.439
West Well, 15 miles south of, on west side of road; iron post stamped "1402 Y"-----	1,402.097
West Well, 21 miles south of, 5 miles west of Colorado River at point opposite Parker, on east side of road; iron post stamped "849 Y"-----	848.520

QUADRANGLE WEST OF PARKER.

NEEDLES TO WEST WELL, THENCE 11 MILES SOUTH.

West Well, 3 miles northwest of, on west side of road; iron post stamped "1048 Y"-----	1,048.925
West Well, 5 miles southwest of, on east side of road; iron post stamped "1232 Y"-----	1,233.121

NEEDLES SPECIAL QUADRANGLE.

LIVERPOOL LANDING, NORTH ALONG CALIFORNIA SIDE OF RIVER TO MELLEN, ARIZ.

Mellen, 15 miles southeast of, 0.45 mile west of river, 10 feet east of foot of mesa, in open flat; iron post stamped "431 Y"-----	431.547
Chemehuevis Valley, 2.5 miles northeast of triangulation signal at the northern end (California side) of, 600 feet west of Colorado River, near Mohave Rock; iron post stamped "437 Y"-----	438.060

MELLEN, NORTHWEST ALONG ATCHISON, TOPEKA AND SANTA FE RAILROAD, TO NEEDLES.

Needles, 4.25 miles south of, on west side of railroad, 6 feet east of milepost 373; iron post stamped "473 Y 1903"-----	474.030
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BENCH MARKS IN THE VICINITY OF NEEDLES.

Needles, Santa Fe station, at road crossing opposite dining room, west front; top of rail-----	481.646
Needles, U. S. Coast and Geodetic Survey, East Base, in stone monument; bronze tablet stamped "467 Y 1903"-----	467.292
Needles, U. S. Coast and Geodetic Survey, West Base, in stone monument; copper bolt (in top) stamped "U. S. G. S. B. M. 490"-----	491.082
Needles, U. S. Coast and Geodetic Survey, stone monument on Knoll triangulation station; point on southeast corner stamped "U. S. G. S. B. M. 680"-----	680.257
Needles, west corner of schoolhouse grounds, iron pipe in top of; concrete monument stamped "552 Y 1903"-----	552.487
Needles, U. S. Coast and Geodetic Survey monument in Catholic churchyard; bronze tablet stamped "503 Y 1903"-----	503.608

NEEDLES, NORTH 9 MILES (PART OF CIRCUIT TO FORT MOHAVE).

Needles, 3 miles northwest of, in sec. 13, T. 9 N., R. 22 E., on west side of road, west of river; iron post stamped "482 Y"-----	482.459
Needles, 8 miles northwest of, in sec. 22, T. 9 N., R. 22 E., on east side of road west of river; iron post stamped "488 Y"-----	488.276

NEEDLES, SOUTH ALONG ROAD, TO WEST WELL.

	Feet.
Needles, 5 miles south of, in sec. 20, T. 8 N., R. 23 E., on east side of road leading to Parker; iron post stamped "737 Y"-----	737.991
Needles, 10 miles south of, in sec. 7, T. 7 N., R. 23 E., on east side of road leading to Parker; iron post stamped "1215 Y"-----	1,215.367
Needles, 15 miles south of, on west side of road leading to Parker; iron post stamped "1933 Y"-----	1,934.152
Needles, 20 miles south of, on west side of road leading to Parker; iron post stamped "1906 Y"-----	1,906.584
Needles, 25 miles south of, 8 miles northwest of West Well, on west side of road; iron post stamped "1613 Y"-----	1,613.262

NEEDLES, NORTHWEST ALONG ATCHISON, TOPEKA AND SANTA FE RAILROAD, TO KLINEFELT.

Needles, 7 miles northwest of, 80 feet east of section house at Java station; iron post stamped "968 Y"-----	969.168
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QUADRANGLE WEST OF NEEDLES SPECIAL QUADRANGLE.

AT KLINEFELT STATION.

Klinefelt station, west side of track, opposite station signboard; iron post stamped "1213 Y"-----	1,213.414
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CAMP MOHAVE QUADRANGLE.

FORT MOHAVE, SOUTH TO POINT 9 MILES NORTHWEST OF NEEDLES.

Fort Mohave, 4 miles southwest of, on road leading to Needles, on west side of river, at foot of knoll on west side of road; iron post stamped "479 Y"-----	479.544
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HOLTVILLE, IMPERIAL, AND SALTON QUADRANGLES.

SAN DIEGO COUNTY.

The elevations in the following list are based on a secondary bench mark on the double primary-level line from San Bernardino to Yuma, a railroad spike in the base of milepost 667, 1 mile east of Old Beach station, Southern Pacific Railroad, 45 feet south of track, the accepted elevation being 104.360 feet below sea level.

The leveling was begun by Mr. W. V. Hardy, levelman, in 1904, and completed by Mr. S. N. Stoner, topographic aid, in 1905.

SALTON QUADRANGLE.

OLD BEACH, SOUTH ALONG SOUTHERN PACIFIC RAILROAD (IMPERIAL AND GULF BRANCH), TO ROCKWOOD SIDING.

	Feet.
Old Beach, 1 mile east of, milepost 667, 45 feet south of track; spike in base (below sea level)-----	— 104.360
Alamo River, 200 feet north of railroad bridge, 45 feet east of track; iron post stamped "— 162 Y"-----	— 161.263
Rockwood siding, 2 feet east of signboard; iron post stamped "— 157 Y"-----	— 156.583

IMPERIAL QUADRANGLE.

BRAWLEY, SOUTH TO IMPERIAL.

	Feet.
Brawley, 0.5 mile north of, 3 feet east of milepost 684; iron post stamped "— 117 Y"-----	— 117. 186
Brawley station, 60 feet north of, at street crossing; top of rail-----	— 112. 102
Brawley triangulation station; iron post stamped "— 93 Y"-----	— 92. 374
Brawley, 3.5 miles south of, 5 feet south of milepost 688, west of track; iron post stamped "— 119 Y"-----	— 118. 248
Imperial, 5 miles north of, at southwest corner of fence; iron post stamped "— 91 Y"-----	— 90. 175
Imperial, 3 miles north of, 30 feet north of wagon-road bridge over arroyo, west of road under second bank; iron post stamped "— 88 Y"-----	— 87. 138
Imperial, south wall of Imperial Hotel; bronze tablet stamped "— 61 Y"-----	— 59. 853
Imperial triangulation, station, 2,000 feet north of railroad station, 40 feet south of spur, east of main track; iron post stamped "— 66 Y"-----	— 65. 437

IMPERIAL, 1.8 MILES EAST TO CROSSROADS; THENCE SOUTH TO CALEXICO.

Imperial, 1.8 miles east of, in southeast angle of crossroads, 3 feet west of fence corner; iron post stamped "— 67 Y"-----	— 67. 110
Holtville, 60 feet south of, at Interurban Railroad crossing, west of road, 10 feet north of fence corner; iron post stamped "— 50 Y"-----	— 49. 121
Holtville, 2.9 miles south of, 100 feet south of Southern Pacific Railroad crossing, east of road; iron post stamped "— 22 Y"-----	— 21. 186
Heber siding, 2 feet east of crossing signboard; iron post stamped "— 14 Y"-----	— 13. 049

CALEXICO, WEST TO VICINITY OF INTERNATIONAL BOUNDARY MONUMENT NO. 221.

International boundary monument No. 221, northeast corner iron base-----	4. 252
International boundary monument No. 221, 0.6 mile west of; on north bank of Wisteria canal; iron post stamped "4 Y"-----	4. 859

BRAWLEY, WEST TO NEW RIVER.

Brawley, 1.5 miles west of, 80 feet east of New River Bridge, 30 feet south of road, 10 feet east of mesquite tree; iron post stamped "— 133 Y"-----	— 132. 206
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HOLTVILLE QUADRANGLE.

CALEXICO, NORTH 2 MILES.

Calexico, north wall of bank building; bronze tablet stamped "+ 5 Y"-----	5. 644
Calexico, 2 miles north of, southwest corner of bridge over main canal; iron post stamped "+ 2 Y"-----	2. 569

INTERNATIONAL BOUNDARY MONUMENT NO. 219, EAST TO HOLT CANAL.

Calexico, 10 miles east of, 100 feet north of Holt canal, 70 feet south of Hemlock canal, 45 feet north of telephone line; iron post stamped "35 Y" ^a -----	35. 887
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^a Bench mark determined by a single unchecked line.

CALEXICO, ACROSS COUNTRY TO INTERNATIONAL BOUNDARY MONUMENT NO. 215.

	Feet.
Calexico, 1.5 miles east of, International boundary monument No. 220, 2 feet east of; iron post stamped "6 Y" (from report, 1.804)-----	6.998
Calexico, 3.6 miles east of, north of road, west end of bridge over main canal; iron post stamped "17 Y"-----	18.134
Calexico, 4.6 miles east of, International boundary monument No. 219; top of bolt in base of shaft, north side (from report, 19.652)-----	25.046
Calexico, 4.6 miles east of, 6 feet north of Boundary monument No. 219; iron post stamped "26 Y"-----	26.942
Sharp triangulation station; iron post-----	60.693
Boundary monument No. 217; northeast corner of cement base (from report, 51.739)-----	55.782
Boundary monument No. 217, 9 feet north of; iron post stamped "56 Y"-----	56.878
Boundary monument No. 216, 1 mile west of; nail in top of 4 by 4 inch boundary stake-----	71.815
Boundary monument No. 215; northeast corner of cement base (from report, 93.144)-----	96.114
Boundary monument No. 215, 6 feet north of; iron post stamped "96 Y"-----	97.113

CABAKER JUNCTION, ALONG HOLTVILLE INTERURBAN RAILROAD TO HOLTVILLE; THENCE ALONG ROAD 2.8 MILES EAST; THENCE SOUTHEAST TO BOUNDARY MONUMENT NO. 215.

Brice siding, 75 feet east of east end of switch, 35 feet south of track; iron post stamped "— 48 Y"-----	— 47.419
Gleason siding, 45 feet south of track, midway between switch targets; iron post stamped "— 58 Y"-----	— 57.115
Holtville, at northeast corner of Alamo Hotel; bronze tablet stamped "— 12 Y"-----	— 9.114
Holtville, 2.8 miles east of, at corner of fence, 60 feet west of No. 5 canal; 1,000 feet north of drop in canal near township corner; iron post stamped "— 7 Y"-----	— 6.022
T. 16 S., R. 16 E., 400 feet west of quarter corner sec. 10, south side; iron post stamped "19 Y"-----	19.534

INTERNATIONAL BOUNDARY MONUMENT NO. 219, OVER MESA TO WAGON BRIDGE OVER ALAMITOS CANAL; THENCE ALONG COUNTY ROAD TO HOLTVILLE.

Boundary monument No. 219, 6 feet north of; iron post stamped "26 Y"-----	26.942
Alamitos canal, bridge near quarter corner between sections 28 and 33, 10 feet east of northeast corner; iron post stamped "12 Y"-----	12.648
Holtville, 1 mile south of, at triangulation station; top of iron post stamped "6 Y"-----	6.581

SUNSET SPRINGS, ACROSS COUNTRY AND ALONG ROAD TO HOLTVILLE.

Sunset Springs, 4.5 miles southwest of, west side of main canal No. 5, at north side of headgate to Oak canal; iron post stamped "— 53 Y"-----	— 51.759
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HOLTVILLE, EAST ACROSS COUNTRY TO 2.5 MILES EAST OF HARDY TRIANGULATION STATION; THENCE TO SUNSET SPRINGS.

Holtville, 6.1 miles east of, at old beach rim; iron post stamped "57 Y"-----	57.792
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	Feet.
Holtville, 10 miles northeast of; iron post stamped "79 Y"-----	79.829
Holtville, 13 miles northeast of, east of low sand ridge; iron post stamped "112 Y"-----	112.834
Hardy triangulation station, 2.5 miles west of, on summit of hill; iron post stamped "140 Y"-----	140.913
Hardy triangulation station, 6 miles northwest of; iron post stamped "100 Y"-----	100.951
Sunset triangulation station, 4 miles east of, 1 mile northeast of Deer Park; iron post stamped "76 Y"-----	77.010
Sunset triangulation station, on summit; iron post stamped "97 Y"---	97.875
Sunset Springs, 10 feet west of; iron post stamped "--44 Y"-----	-42.719

INTERNATIONAL BOUNDARY MONUMENT NO. 215, ACROSS COUNTRY, TO 2.5 MILES WEST OF HARDY TRIANGULATION STATION.

Boundary monument No. 215, 4.5 miles northeast of; iron post stamped "131 Y"-----	131.843
Boundary monument No. 215, 8 miles northeast of; iron post stamped "132 Y"-----	132.809
Boundary monument No. 215, 11 miles northeast of; iron post stamped "128 Y"-----	128.796
Boundary monument No. 215, 14.3 miles northeast of, 0.75 mile south of Hardy triangulation station, west edge of sand; iron post stamped "132 Y"-----	132.714

INTERNATIONAL BOUNDARY MONUMENT NO. 217, ACROSS MESA AND ALONG ROAD, TO HOLTVILLE.

Holt and Hickory canals 50 feet south of junction, south of road west of Holt canal, northeast corner of wire fence; iron post stamped "14 Y"-----	15.216
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SUNSET SPRINGS, WEST TO J. W. HART'S RESIDENCE AND RETURN.

Residence of J. W. Hart, 150 feet south of, 15 feet north of check in Orchard canal; iron post stamped "--123 Y"-----	-121.705
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CAMPO, CUYAMACA, JAMUL, LA JOLLA, AND SAN DIEGO QUADRANGLES.

SAN DIEGO COUNTY.

The elevations in the following list are based upon a bronze tablet in the foundation pier, north of the southeast corner of east wing of the San Diego County court-house, 4 feet above ground, stamped "S D". The elevation of this is now accepted as 42.342 feet above mean sea level as obtained by United States Coast and Geodetic Survey precise leveling of 1906 from Point Loma, which recovered also other bench marks of this list at American Park, Linda Vista, and Sorrento.

The double-rodged line Green Valley to San Diego, on La Jolla and San Diego quadrangles, was run in 1898 by Mr. George H. Herrold, levelman; other work on these two quadrangles was done in 1901 under Mr. J. E. Rockhold, topographer, by Mr. W. V. Hardy, levelman, and also on San Diego quadrangle in 1902 under Mr. E. T.

Perkins by Mr. C. L. Nelson. The leveling on Cuyamaca quadrangle was done under Mr. E. T. Perkins in 1901-2, by Mr. Hardy, and in 1902 by Mr. Nelson.

STANDARD BENCH MARKS OF THE UNITED STATES COAST AND GEODETIC SURVEY ON SAN DIEGO AND LA JOLLA QUADRANGLES.

SAN DIEGO QUADRANGLE.

	Feet.
San Diego, tidal 7, directly over tidal 6, in the surface of a cement collar or encasement built around the pile as a protection against destructive sea life, toward the northwest corner of the cement; three-fourths-inch hole 2 inches deep filled with babbitt metal (a rod held upon this point clears the north side of the pier)-----	1.959
San Diego, tidal 3, in the United States Quarantine Grounds, near the inner end of the pier and southwest of the blacksmith shop, at center of the top of a cement monument, 1 foot square and 2 feet long, projecting 1 foot above the ground, resting upon a pier built of rock and cement upon the sand, 3 feet deep, 2.5 by 4 feet at the bottom, and 2 by 1.5 feet at the top; monument mark "U. S. C. S. 1906" and two diagonal lines, with a light dot at the center-----	6.167
San Diego, tidal 2, near the northeast corner of the residence of the quarantine surgeon, on the cover of a sewer, in a granite slab 4 feet square, resting on a brick foundation and having an iron-covered manhole 2 feet in diameter in its center; drill hole filled with lead (3½ inches from the edge of the iron cover and northwest of the center of the manhole)-----	10.086
San Diego, tidal 5, in the United States Quarantine Grounds, near the southeast corner of the Cottage Hospital, on the cover of a sewer, a granite slab 4 feet square, cemented upon masonry and having an iron manhole 2 feet in diameter in its center; three-fourths-inch hole 2 inches deep, filled with babbitt metal flush with the surface (6.5 inches from the manhole, on the southeast corner)-----	7.780
San Diego, tidal 4, outside the United States Quarantine Grounds, near the northwest corner, about 110 feet north of the fence; cement pier or monument similar to tidal 3 (the soil at the depth of 3 feet and for about a foot above is almost a hardpan)-----	12.486
San Diego, tidal 1, about 400 feet almost due north of the northwest corner of the United States Quarantine Grounds; center of the top of a granite block 10 inches square-----	8.721
A. About 1.25 miles north of Roseville, Point Loma, set in hardpan, at the inside corner of the public road leading from Roseville to Old Town, in range with the telephone poles and 1 meter south of the pole set in the corner; Coast Survey iron B. M. post-----	33.319
B. About 1½ miles north of San Diego, on the Atchison, Topeka and Santa Fe Railway right of way, about 50 meters north of milepost 266, on west end of concrete culvert "C 266" in the corner of the horizontal surface, 2½ meters below the rail; Coast Survey B. M. tablet-----	20.622
C. San Diego, at southwest corner of Fir and California streets, on the Atchison, Topeka and Santa Fe Railway right of way, 3 meters west of track, on west side of iron rim to a manhole; surface within an outlined square 1 inch on each side-----	23.560

LA JOLLA QUADRANGLE.

	Feet.
D. Old Town, about 100 meters east of the Atchison, Topeka and Santa Fe Railway, set in hardpan, in the southwest corner of the public school grounds; stone post 4 feet long by 6 inches square, projecting 6 inches above ground, with a hole cut in top 2.5 centimeters square and about 4 millimeters deep, bottom of which is B. M. (top of post lettered "U. S. B. M.")-----	25. 428
E. About 1 mile north of Atwood, on the Atchison, Topeka and Santa Fe Railway right of way, at west end of concrete culvert F 260, in center of the horizontal surface; three-eighths-inch copper bolt 2 inches long, set (in lead or cement) flush with surface-----	62. 942
F. About 1.25 miles northwest of Ladrillo, 25 meters northwest of milepost 258, set in clay, in the corner of a fence, one-third meter east of the Atchison, Topeka and Santa Fe Railway right of way; iron post, same as "A"-----	97. 088
G. Selwyn, on the Atchison, Topeka and Santa Fe right of way, about 80 meters west of signboard "Selwyn," 16 meters north of track; stone post, same as "D"-----	232. 428
H. Sorrento, about 75 meters southwest of the Atchison, Topeka and Santa Fe Railway station, in the corner of the fence, on land owned by John Works; stone post, same as "D"-----	40. 422
I. About 1 mile south of Del Mar, on the Atchison, Topeka and Santa Fe right of way, 1 meter south of the second telegraph pole south of the road crossing, 15 meters east of the track and set in sand 3 meters above rail; iron post, same as "A"-----	151. 995
J. Del Mar, on West Tenth street, about 100 meters west of the Atchison, Topeka and Santa Fe right of way, on land owned by J. W. Bennett, on the east face of the old cement foundation in center of the vertical surface, three-fourths meter above ground; copper bolt, same as "E"-----	90. 533

STANDARD BENCH MARKS OF THE UNITED STATES GEOLOGICAL SURVEY.

LA JOLLA QUADRANGLE.

GREEN VALLEY, SOUTH ALONG ROAD, TO POWAY DIVIDE; THENCE SOUTHWEST, VIA LINDA VISTA MESA AND MURRAY CANYON, TO NORTH (OLD TOWN) SAN DIEGO (DOUBLE-RODDED LINE).

Watson's ranch, 5 feet east of fence corner, north side of Powey road, at junction with San Diego road; iron post stamped "585"-----	585. 941
Merton post-office, southeast corner of junction of Poway and San Diego road; iron post stamped "438"-----	438. 890
Poway divide, on south side of road; iron post stamped "967"-----	967. 900
Virginia post-office, 0.75 mile southwest of, in forks of road where road down valley leaves San Diego road; iron post stamped "578"-----	578. 897
Linda Vista Mesa, junction of Escondido and Linda Vista road, 8.5 miles north of San Diego; iron post stamped "417"-----	417. 393
Linda Vista Mesa, head of grade out of Mission Valley, on east side of Escondido road and south end of mesa road; iron post stamped "394"-----	394. 357
County Hospital, north of, west side of road to San Diego and 40 feet south of road to Old Town; iron post stamped "28"-----	28. 378

PRIMARY LEVELING.

43

	Feet.
Old Town (San Diego), south and east of motor track, in west wall at northwest corner of brick building, 2.6 feet above porch floor; copper bolt stamped "U. S. G. S. 44 ft. B. M."-----	44.335

SAN DIEGO COUNTY HOSPITAL, ALONG COUNTY ROAD, TO MORENA; THENCE ALONG SAN DIEGO, PACIFIC BEACH AND LA JOLLA RAILWAY TO RACE TRACK; THENCE ALONG SOUTHERN CALIFORNIA RAILWAY TO SORRENTO.

Moreno, in front of station; top of rail-----	15.6
Race Track, southwest corner of station; top of rail-----	21.0
American Park race track, 710 feet north of station, at southwest angle of junction of road to Pacific Beach; iron post stamped "25 S D" (recovered by U. S. Coast and Geodetic Survey)-----	25.433
Ladrillo, 2 miles north of, 600 feet west of G. N. Gilbert's ranch house; at junction of road to house with road from San Diego to Sorrento; iron post stamped "176 S D"-----	176.640
Selwyn, at signboard; top of rail-----	236.3
Linda Vista, 25 feet west of section house, 10 feet east of siding, in northwest corner of yard; iron post stamped "376 S D" (recovered by U. S. Coast and Geodetic Survey)-----	376.706

LINDA VISTA, EAST ALONG WAGON ROAD TO VIRGINIA.

Linda Vista, 2.4 miles east of, at northwest angle of intersection of roads; iron post stamped "452 S D"-----	452.895
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SORRENTO, EAST ALONG COUNTY ROAD, TO MERTON.

Sorrento, in front of station; top of rail-----	31.8
Sorrento, 35 feet north of station, 15 feet northwest of section house, 25 feet east of road crossing; iron post stamped "31 S D" (recovered by U. S. Coast and Geodetic Survey)-----	31.611
Los Perasquitos ranch house, 0.7 mile east of, at intersection of roads; iron post stamped "245 S D"-----	245.743

SORRENTO, NORTH 1.5 MILES ALONG SOUTHERN CALIFORNIA RAILWAY; THENCE BY WAGON ROAD, VIA SAN DIEGUITO SCHOOLHOUSE, TO LOS PERASQUITOS RANCH.

San Dieguito schoolhouse, 2 feet west of, 1 foot south of porch, at entrance; iron post stamped "53 S D"-----	53.606
San Dieguito schoolhouse, 4.3 miles east of, at junction of roads; iron post stamped "348 S D"-----	348.742

SAN DIEGO COUNTY HOSPITAL, VIA COUNTY ROAD UP SAN DIEGO RIVER, TO OLD MISSION DAM; THENCE SOUTH TO LA MESA.

Grantville, at entrance to schoolhouse, on west side of porch; iron post stamped "123 S D"-----	123.456
Old Mission dam, 125 feet southeast of, 100 feet south of San Diego River, 70 feet north of road, 35 feet east of windmill; iron post stamped "288 S D"-----	288.513
La Mesa Springs, at northeast corner of La Mesa Lemon Company's store, in brick front, 2.5 feet above porch floor; bronze tablet stamped "539 S D"-----	540.061

LA MESA SPRINGS, WEST ALONG COUNTY ROAD VIA SAN DIEGO NORMAL SCHOOL, TO SAN DIEGO.

	Feet.
San Diego Normal School, at east side of main entrance, in south face of baluster, set flush with vertical surface 3 feet above ground; bronze tablet stamped "355 S D"-----	356.024

SAN DIEGO QUADRANGLE.

QUARANTINE STATION, NORTHEAST TO NORTH SAN DIEGO (OLD TOWN); THENCE SOUTH ALONG PACIFIC BEACH MOTOR TRACK TO SAN DIEGO (DOUBLE-RODDED LINE).

Quarantine station, north of, on Point Loma, U. S. Coast and Geodetic Survey bench mark, "Tidal 1," granite block 10 inches square on top, marked "U. S." (north side marked "Ref. Mark," east side marked "Coast Survey," south side marked "1853-54-55," north side marked "for tide," latest value)-----	8.721
Roseville, at southeast corner of fenced school grounds; iron post stamped "35" (recovered by U. S. Coast and Geodetic Survey)-----	35.295
San Diego County court-house, in the foundation pier north of southeast corner of east wing, 4 feet above ground; bronze tablet stamped "42 S D"-----	42.342
San Diego, City B. M., City Hall Building, corner Third and D streets; north corner of stone steps ^a (recovered by U. S. Coast and Geodetic Survey)-----	46.119
San Diego, in brick wall of west front of Creigne Building, 2 feet above step north of door, corner of Fourth and K streets; old U. S. Coast and Geodetic Survey bench mark, Geological Survey elevation-----	12.20

SAN DIEGO COURT-HOUSE, VIA NATIONAL CITY AND OTAY RAILWAY, TO OTAY.

San Diego, intersection of Front street and Southern California Railway track; top of rail-----	8.0
San Diego, at crossing of the National City and Otay and the San Diego, Cuyamaca and Eastern railways; top of rail-----	9.7
National City, at intersection of National avenue and First street; top of rail-----	27.0
National City, at Twenty-fifth street, 60 feet north of school, east of road; iron post stamped "57 S D"-----	57.832
Sweetwater Junction; top of rail-----	23.5
Chulavista, in front of station; top of rail-----	74.2
Otay, 1.5 miles south of schoolhouse, 1 foot east of porch, at east side of entrance; iron post stamped "62 S D"-----	62.572

SWEETWATER JUNCTION, VIA NATIONAL CITY AND OTAY RAILWAY, TO LA PRESA; THENCE NORTH TO LA MESA.

Bonita store, in front of platform; top of rail-----	60.3
Sweetwater schoolhouse, 85 feet northwest of, 25 feet south of road and 15 feet south-southeast of pepper tree; iron post stamped "65 S D"-----	65.554
Sunnyside, in front of station; top of rail-----	93.5
Aloha, in front of station; top of rail-----	152.2
La Presa, 1 mile southwest of, 130 feet northeast of signboard at intersection of roads; iron post stamped "238 S D"-----	238.566

^a The elevation of this bench mark by the city datum is 40 feet.

OTAY, ALONG COUNTY ROAD EAST, TO WEST LINE OF OTAY RANCH.

	Feet.
T. 18 S., R. 1 W., sec. 20, 3 feet north of east gate to Dr. Wiard's field, 2 feet east of west line to Otay ranch, 10 feet northwest of intersection of roads; iron post stamped "149 S D"-----	149.515

JAMUL 15' (CUYAMACA 30') QUADRANGLE.

WEST LINE OF OTAY RANCH, NORTHEAST TO JAMUL RANCH.

Lower Otay dam, 33 feet southeast of east end of sec. 18, T. 18 S., R. 1 E., 70 feet east of intersection of filled road with dam, on northwest face of boulder 4 by 3 by 2 feet; bronze tablet stamped "486 S D"-----	486.569
T. 18 S., R. 1 E., sec. 4, 300 feet northwest of Jones's house, 50 feet northeast of intersection of roads, on top of boulder 3 by 3 by 1.5 feet; bronze tablet stamped "514 S D"-----	514.887

JAMUL RANCH, ALONG COUNTY ROAD NORTH, TO JAMUL POST-OFFICE; THENCE WEST TO LA PRESA.

Jamul, 231 feet northeast of schoolhouse, 3 feet east of southeast corner of Barrett's property, 25 feet northeast of intersection of roads, on top of boulder 2.5 by 2 by 1 foot; bronze tablet stamped "1040 S D"-----	1,040.274
T. 16 S., R. 1 W., on San Bernardino meridian, 2 feet south of northeast corner sec. 36, 400 feet north of Sweetwater River, about 1 mile northeast of forks of road to La Presa and Jamul; iron post stamped "342 S D"-----	342.413

JAMUL RANCH, EAST ALONG COUNTY ROAD 3.5 MILES, TO LYON PEAK ROAD.

Intersection of Jamul and Lyon Peak road with road branching to Lawson Valley, 35 feet northwest of, on south face of boulder 9 by 9 by 9 feet, 4 feet above ground; bronze tablet stamped "1400 S D"-----	1,400.549
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FORKS OF ROAD 3.5 MILES EAST OF JAMUL RANCH, NORTHWEST VIA COUNTY ROAD, TO DIVIDE BETWEEN WOOD VALLEY AND LEE VALLEY.

Jamul, 3.5 miles east of, T. 16 S., R. 2 E., near southwest corner of section 31, on ridge divide between Wood and Lee valleys, at intersection of Lyons and Lawson Valley roads, 8 feet northeast of oak tree; iron post stamped "1789 S D"-----	1,789.549
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JAMUL RANCH, SOUTHEAST ALONG COUNTY ROAD, TO DALZURA.

Dalzura schoolhouse, 120 feet south of, 6 feet north of creek ford, 6 feet north of road, on top of granite boulder; bronze tablet stamped "1243 S D"-----	1,243.680
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CUYAMACA QUADRANGLE.

EAST OF JAMUL RANCH, EAST ALONG COUNTY ROAD, TO MORENA DAM; THENCE SOUTH TO CAMPO.

Pine Valley station, 2.5 miles west of, sec. 5, T. 17 S., R. 3 E., 500 feet southeast of old adobe building, 15 feet north of road at summit, in top of granite boulder; bronze tablet stamped "2108 S D"-----	2,110.642
Morena dam, 0.4 mile north of sec. 14, T. 17 S., R. 4 E., near quarter corner, 170 feet east of road; iron post stamped "3010 S D"-----	3,010.134

DALZURA, SOUTHEAST ALONG COUNTY ROAD, TO CAMPO.

	Feet.
Elsenecke, sec. 8, T. 18 S., R. 3 E., 81 feet west of Barnight's house, 36 feet north of barn, 27 feet north of road, in granite boulder, 1 foot above ground; bronze tablet stamped "875 S D"-----	875. 539
Potrero, 300 feet west of post-office, sec. 18, T. 18 S., R. 4 E., at intersection of roads, 0.7 foot below top of boulder 4 feet high; iron post stamped "2323 S D"-----	2, 323. 478
T. 18 S., R. 4 E., sec. 24, at first crossing of Campo Creek, 200 feet west of ford, 3 feet north of road, 100 feet east of turn, on south face of boulder 10 by 7 by 8 feet; bronze tablet stamped "2189 S D"-----	2, 189. 483

FORK OF ROAD, 2.5 MILES NORTHWEST OF PINE VALLEY STATION, NORTH ALONG COUNTY ROAD, TO DESCANSO; THENCE SOUTHEAST, VIA PINE VALLEY POST-OFFICE, TO MORENA DAM.

Japatul schoolhouse, 12 feet southeast of, sec. 15, T. 16 S., R. 3 E., in top of granite boulder 2.5 by 2.5 by 2 feet; bronze tablet stamped "2866 S D"-----	2, 866. 166
Descanso, 1.5 miles east of, 2 feet south of signpost, on west side of road, at junction of road to Campo; iron post stamped "3541 S D" ^a -----	3, 541. 126

PINE VALLEY POST-OFFICE, SOUTHWEST ALONG COUNTY ROAD, TO CORTE MADARA.

Corte Madara ranch house, 85 feet north of, sec. 21, T. 16 S., R. 4 E.; in top of granite boulder 6 by 6 by 1.5 feet; bronze tablet stamped "3965 S D"-----	3, 965. 135
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DESCANSO, ALONG WAGON ROAD NORTHWEST, TO SUMMIT EAST OF VIEJAS VALLEY.

T. 15 S., R. 3 E., sec. 14, 3 miles west of Descanso, 16 feet southeast of road on summit east of Viejas Valley, in top of granite boulder 3 by 3 by 1.5 feet; bronze tablet stamped "3672 S D"-----	3, 672. 448
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FORKS OF ROAD, 1.5 MILES EAST OF DESCANSO, NORTH ALONG COUNTY ROAD VIA CUYAMACA, TO JULIAN. ^b

Twin Pine Springs, 1.4 miles south of, 10 feet east of road, at junction of road running east to Mr. Hobb's house; iron post stamped "4132 S D"-----	4, 132. 421
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CAMPO QUADRANGLE.

AT CAMPO.

Campo, 30 feet west of custom-house, 100 feet southeast of store, on vertical face of boulder 15 by 30 by 20 feet, 3 feet above ground; bronze tablet stamped "2543 S D"-----	2, 543. 511
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^a No standard bench marks were left on remainder of this line.

^b This line, rerun as far as Cuyamaca, still closes 1.6 feet high on accepted height of Julian in the list on Ramona quadrangle.

CAPISTRANO, CLARK LAKE, CORONA, ELSINORE, ESCONDIDO, INDIO SPECIAL, OCEANSIDE, RAMONA, RIVERSIDE, SALTON, SAN JACINTO, AND SAN LUIS REY QUADRANGLES.

ORANGE, RIVERSIDE, AND SAN DIEGO COUNTIES.

The elevations in the following list are based upon the precise-level line run by the United States Coast and Geodetic Survey in 1906 along the Atchison, Topeka and Santa Fe Railroad from Point Loma (near San Diego), which recovered many bench marks of this list. They are also corrected in agreement with a checked primary-level line run by Mr. R. A. Farmer, topographer, east along the Southern Pacific Railroad from Colton to Montmere, checked throughout within primary limits by comparison with a former double-rodged line of 1898 by Mr. George H. Herrold, Colton to Palm Springs, and by a single line of 1901, thence to Montmere, by Mr. C. C. Ward, a third running being made when necessary.

Leveling on Capistrano and Corona quadrangles was done in 1899 under Mr. L. C. Fletcher, topographer; on Escondido, Oceanside, San Luis Rey, and south edge of Elsinore quadrangles in 1899 under Mr. W. T. Turner, topographer, on Ramona quadrangle in 1900; and on Clark Lake, Indio Special, and Salton quadrangles in 1901, by Mr. Ward, levelman. Leveling was also done on Corona, Elsinore, Riverside, and San Jacinto quadrangles in 1897 and 1898 and a double-rodged line on Escondido and San Luis Rey quadrangles in 1898 by Mr. Herrold, levelman, and on Corona quadrangle in 1899 by Mr. C. R. Smith, levelman.

A portion of these bench marks are stamped "S B," referring to San Bernardino, but the elevation now accepted there is 0.7 greater than the elevation previously published.

STANDARD BENCH MARKS OF THE UNITED STATES COAST AND GEODETIC SURVEY ALONG THE ATCHISON, TOPEKA AND SANTA FE RAILWAY.

OCEANSIDE QUADRANGLE (SAN LUIS REY 30' QUADRANGLE).

	Feet.
K. About 1.25 miles southeast of Encinitas, on the Atchison, Topeka and Santa Fe right of way, at the southwest end of the concrete culvert A 240, in the center of the horizontal surface of the coping; copper bolt-----	72.734
L. Encinitas, 0.25 mile west of the Atchison, Topeka and Santa Fe Railway station, at the corner of Third and E streets, in the public school grounds, in the middle of the front yard, about 35 meters east of the schoolhouse; iron pipe, set in cement. (U. S. C. & G. S. B. M. post)-----	91.942
M. About 0.66 mile southeast of Carlsbad, 1 telegraph pole northwest of milepost 230, at the east corner of the road crossing, on the public highway, at the intersection of the Atchison, Topeka and Santa Fe right of way and the cattle-yard fences; bottom of a hole 2.5 cm. square and about 4 mm. deep, cut in top of a stone post whose top is 6 inches square, projecting 6 inches above ground, and lettered "U. S. B. M" -----	44.156

	Feet.
N. Carlsbad, about 175 meters southwest of the Atchison, Topeka and Santa Fe Railway station, in the park owned by the Huntington Syndicate Company, at the east corner of the most northerly house, at the south end of the first concrete basement step; copper bolt, same as "K"-----	55.492
O. Oceanside, about 60 meters south of the Atchison, Topeka and Santa Fe Railway station, on railroad property, about 10 meters southwest of the track, and one-third meter outside of the fence; stone post with hole, same as "M"-----	44.420
P. Oceanside, on the south corner of First and Ditmar streets, in the northeast side of the First Methodist Episcopal Church, 0.66 meter from north corner and 1 meter above ground; copper bolt, same as "K"-----	83.805
Q. Oceanside, at the west corner of Second and Hill streets, on the step of the side entrance to the Bank of Oceanside Building; surface of an outlined square 1 inch on each side, unlettered-----	67.627
R. Oceanside, on the northwest side of Third street, between Tremont and Hill streets, in the brick store, 2½ blocks northeast of the Atchison, Topeka and Santa Fe Railway; Coast Survey B. M. tablet-----	64.438

SAN LUIS REY 30' QUADRANGLE.

S. About 0.66 mile southeast of Las Flores, on the Atchison, Topeka and Santa Fe right of way, 9½ telegraph poles southeast of milepost 219, 12 meters southwest of track; iron pipe set in clay, same as "L"-----	74.952
T. About one-third mile southeast of Las Flores, on the Atchison, Topeka and Santa Fe right of way, 1½ telegraph poles southeast of milepost 219, at the southwest end of concrete culvert A 220, in horizontal surface of coping, one-third meter from northwest corner, 3 meters below rail; copper bolt, same as "K"-----	58.324
U. Don, about 45 meters west of signboard "Don," between the Atchison, Topeka and Santa Fe right-of-way fence and the first telephone pole northwest of the warehouse; stone post with hole, same as "M"-----	136.736

CAPISTRANO QUADRANGLE.

V. Four-tenths mile west of San Onofre, about 150 meters west of the county road crossing, on the north side of the county road, one-third meter south of the Atchison, Topeka and Santa Fe right of way; stone post with hole, same as "M"-----	9.985
W. One-third mile northwest of Mateo, about 75 meters east of the Atchison, Topeka and Santa Fe Railway, 3 meters north of the county road, and 4 meters west of the bridge, near the corner of a fence; iron pipe, same as "L"-----	15.117
X. Two-thirds mile north of Serra, opposite the second telegraph pole southwest of milepost 199, one-half meter southeast of the Atchison, Topeka and Santa Fe right of way, in corner of a fence, at foot of a hill; iron pipe, same as "L"-----	41.252
Y. San Juan Capistrano, northeast of the Capistrano mission, in the southwest corner of the public school grounds; post-----	120.762

CORONA 30' QUADRANGLE.

	Feet.
Z. San Juan Capistrano, 0.25 mile north of the Atchison, Topeka and Santa Fe Railway station, on the right of way, about 100 meters north of milepost 197, at the east end of a large concrete culvert, on the horizontal surface of the coping, one-third meter from north end; tablet, same as "R"-----	115.741
A. About 4½ miles south of El Toro, on the Atchison, Topeka and Santa Fe right of way, 1 telegraph pole north of the road crossing, at the west end of concrete culvert A 193, on the center of the horizontal surface of the coping; surface of a square 1 inch on each side, marked "U. S."-----	279.973
B. About 1½ miles southeast of Irvine, opposite half-mile pole 194½, at the corner of the public road, one-third meter north of the Atchison, Topeka and Santa Fe right of way; stone post with hole, same as "M"-----	258.079
C. Irvine, 40 meters south of the Atchison, Topeka and Santa Fe Railway station, in the north corner of the public school grounds; stone post with hole, same as "M"-----	193.913
D. One-half mile south of Alliso, on the public highway, at the southwest corner of the road crossing near milepost 178; iron pipe, same as "L"-----	81.256
E. Santa Ana, about 1½ miles southeast of the Atchison, Topeka and Santa Fe Railway station, 3½ telegraph poles west of milepost 177, at road crossing, on the south side of the track, in the horizontal surface of the irrigation culvert; copper bolt, same as "K"-----	105.661
F. Santa Ana, one-third mile south of the Atchison, Topeka and Santa Fe Railway station, on the north side of Chestnut street, between the Southern Pacific Railway and the Atchison, Topeka and Santa Fe Railway; highest point of star on top of hydrant-----	122.972
City, Santa Ana, on the northwest corner of Third and Garfield streets; copper wire set in center of a cement block-----	128.023
G. Santa Ana, on the northwest corner of the City Hall, in water table, facing Third street, 1½ meters above the walk; tablet, same as "R"-----	124.144
H. Santa Ana, at the main entrance to the court-house, on the southeast corner of the east granite balustrade, 1 meter above the walk; 1 inch square, same as "Q"-----	133.341
I. Orange, in the center of the west side of the plaza, 5 meters east of the west fence; iron pipe, set in cement, same as "L"-----	187.024
J. Orange, in the Orange Union High School Building, at the north side of the main entrance, in the vertical surface of the concrete water table, one-third meter above the balustrade; tablet, same as "R"-----	197.497
K. About 1½ miles north of Orange, about 45 meters north of milepost 46, in the southeast corner of road crossing, on land of N. T. Edwards; stone post with hole, same as "M"-----	188.466
L. Olive, about 225 meters northeast of the Atchison, Topeka and Santa Fe Railway station, in the public school grounds, in the angle formed by the west side of the front entrance and the main building, set in gravel; iron pipe, same as "L"-----	274.166

	Feet.
M. About seven-eighths mile north of Olive, on the Atchison, Topeka and Santa Fe right of way, about 165 meters south of milepost 43, at the northeast corner of the plate girder bridge A 44, on the northeast corner of the steel base, about two-thirds meter below the rail; outlined square, in iron, same as "Q"-----	241. 070
N. Richfield, about 40 meters north of the railroad station, in northwest corner of highway junction, on range with telephone poles; stone post with hole, same as "M"-----	246. 365
O. Horse Shoe Bend, 1½ telegraph poles southwest of signboard "Horse Shoe Bend," at the road crossing, 8 meters south of small highway bridge, on the sloping surface of the concrete canal; tablet, same as "R"-----	381. 781
P. About 1½ miles west of Gypsum, on the Atchison, Topeka and Santa Fe right of way, at north end of county culvert C 35, on horizontal surface of coping, one-third meter from east end; copper bolt, lettered "U. S."-----	401. 920
Q. About 1 mile southwest of Crary, on the Atchison, Topeka and Santa Fe right of way, 23 meters south of milepost 29, 14 meters west of track, on north slope of small knoll; iron pipe, same as "L"-----	469. 960
R. About two-thirds mile northeast of Crary, on the Atchison, Topeka and Santa Fe right of way, at the northwest corner of the road crossing; stone post with hole, same as "M"-----	507. 120
S. Corona, directly south of the Atchison, Topeka and Santa Fe railway station, in center of the triangular park belonging to the railroad company; iron pipe, same as "L"-----	606. 256
T. Corona, on the west side of Main street, in the northeast corner of Masonic Block, one-half meter from the east face and 1½ meters above the walk; copper bolt, same as "K"-----	685. 455
City. Corona, at the northwest corner of Main and Sixth streets, 2 meters northeast of the main entrance to the Citizens' Bank; a metal plug set in the cement walk, corresponds to 171.20 feet, city datum-----	673. 761
U. Within the city limits, Riverside, 1 telegraph pole southwest of signboard "Alvord," in the easterly corner of the road crossing, on land owned by J. T. Hammer; iron pipe, same as "L"-----	669. 348

RIVERSIDE 15' QUADRANGLE (ELSINORE 30' QUADRANGLE).

V. Within the city limits, Riverside, about 2.75 miles southwest of Arlington, at the southernmost corner of the road crossing, at milepost 19, 1 meter northwest of telegraph pole; stone post with hole, same as "M"-----	720. 346
W. Within the city limits, Riverside, one-half mile northeast of Arlington, 4 telegraph poles northeast of milepost 16, in the northwest corner of road crossing, on land owned by R. L. Carpenter; stone post with hole, same as "M"-----	846. 068
X. Within the city limits, Riverside, about 1 mile southwest of Casa Blanca, on the Atchison, Topeka and Santa Fe right of way, 2½ telegraph poles northeast of milepost 15, on northwest side of northeast concrete abutment of trestle D 15, on the horizontal surface, at the angle; outlined square, same as "Q"-----	847. 502

	Feet.
Y ₁ . Riverside, on the north side of the county court-house, 2 meters west of northeast corner, in the center of small projection, one-third meter above ground; copper bolt, same as "K"-----	847.944
Z ₁ . Riverside, at the east side of the main entrance to the Carnegie Public Library, on the horizontal surface of the cement balustrade, one-third meter from building; tablet, same as "R"-----	857.405

STANDARD BENCH MARKS BY THE UNITED STATES GEOLOGICAL SURVEY.

CORONA QUADRANGLE.

MAGNOLIA CROSSING, SOUTHWEST ALONG MAGNOLIA AVENUE AND NORTHWEST ALONG HIGHWAY, TO RINCON; THENCE SOUTHWEST, ALONG ROAD, TO OLIVE.

May, 0.25 mile southwest of signboard (within city limits of Riverside), on Magnolia avenue, 250 feet northeast of crossing, in line with center row of trees; iron post stamped "687" (recovered by U. S. Coast and Geodetic Survey)-----	687.776
Corona, at northwest corner of Buena Vista avenue and Limon street (pipe line No. 2); iron post stamped "1049 S B"-----	1,050.291
Crary (Rincon post-office), on north side of street, at southeast corner of post-office and store; iron post stamped "494 S B" (recovered by U. S. Coast and Geodetic Survey)-----	494.559
Rincon, 7.3 miles west of, at head of grade where road finally leaves the sidehill slopes of Santa Ana Canyon, on north side of road; iron post stamped "402 S B"-----	402.576

OLIVE, SOUTHEAST UP SANTIAGO CREEK ROAD, TO DIVIDE; THENCE SOUTHWEST, DOWN ALISO CREEK, TO EL TORO.

Olive, 7.7 miles southeast of, at northeast corner of fence of Orange County Park, 20 feet to the right of road; iron post stamped "610 S B"-----	610.931
Olive, 13.7 miles southeast of, where road to Silverado turns off to east up side of gulch, 8 feet west of main road; iron post stamped "977 S B"-----	978.246
Olive, 17 miles southeast of, along Santiago Creek where Santiago Canyon road begins to climb sidehill to cross divide into Aliso Canyon, en route to El Toro; iron post stamped "1271 S B"-----	1,271.473
Aliso schoolhouse, about 45 feet from, in northwest corner of yard; iron post stamped "1041 S B"-----	1,041.808

EL TORO, SOUTH ALONG SOUTHERN CALIFORNIA RAILROAD, TO CAPISTRANO.

El Toro schoolhouse, 2 feet from front of, in angle formed by porch and building; iron post stamped "444 S B" (recovered by U. S. Coast and Geodetic Survey)-----	444.862
El Toro, 4.33 miles south of, 40 feet east of track, at road crossing, in fence corner; iron post stamped "278 S B"-----	279.093

TEMESCAL, NORTHWEST ALONG ROAD, TO CORONA.

Rugby district school, north side of sec. 21, T. 4 S., R. 6 W., northeast corner of grounds; iron post stamped "897"-----	898.000
Corona, southeast angle of, Porphyry quarry and Corona road; iron post stamped "903"-----	904.977

RINCON, NORTH ALONG ROAD, TO DEL CHINO; THENCE EAST TO LA SIERRA RANCH; THENCE SOUTH TO CORONA.

	Feet.
Chino rancho, where Central avenue crosses road running east and west, in northwest angle of road, 1.5 miles south of Southern Pacific station at Chino; iron post stamped "633 S B"-----	633.481
Chino rancho, at southeast corner of boundary; iron post stamped "602 S B"-----	603.269
La Sierra rancho (Sepulveda), 1 mile south of Cooks Ford, east side of road from Corona; iron post stamped "683 S B"-----	684.083

ESPERANZA SIDING, NORTHERLY VIA WAGON ROAD, TO SAN JUAN TRIANGULATION STATION.

San Juan triangulation station, in top of stone and cement monument; aluminum tablet stamped "1780 S B"-----	1,781.064
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CAPISTRANO, NORTHEAST UP SAN JUAN CANYON.

Capistrano, 2 miles east of, 320 feet east of southwest corner sec. 32, T. 7 S., R. 7 W., north side of road; iron post stamped "149 S B"---	149.898
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CAPISTRANO QUADRANGLE.

CAPISTRANO, SOUTHEAST ALONG SOUTHERN CALIFORNIA RAILROAD, TO LA FLORES.

Capistrano, in northwest corner of flower plot south of station and east of track; iron post stamped "103 S B" (recovered by U. S. Coast and Geodetic Survey)-----	103.919
San Onofre siding, 20 feet front of section bunk house, in yard; iron post stamped "28 S B" (recovered by U. S. Coast and Geodetic Survey)-----	28.666
Don (formerly Jerome), 2.4 miles northwest of, 50 feet east of track, in fence corner on south side of cattle crossing; iron post stamped "165 S B" (recovered by U. S. Coast and Geodetic Survey)-----	165.671

RIVERSIDE 15' QUADRANGLE (ELSINORE 30' QUADRANGLE).

RIVERSIDE, SOUTHWEST ALONG SOUTHERN CALIFORNIA RAILWAY, TO MAGNOLIA AVENUE CROSSING.

Riverside, in alcove on right of main entrance to Loving Opera House, 4 feet above sidewalk, bronze tablet stamped "851" (recovered by U. S. Coast and Geodetic Survey)-----	851.577
Riverside, in alcove on right of main entrance to Loving Opera House, 1 foot above sidewalk, official city bench mark (elevation of which by city datum, as obtained from city engineers, is 848.777); copper bolt-----	848.653
Olivewood Cemetery, at canal crossing, 0.5 mile north of Pachapa siding; iron post stamped "863" (recovered by U. S. Coast and Geodetic Survey)-----	863.387
Casa Blanca, in southeast concrete foundation pier of station platform, 1 foot underground, protected by covered tin cylinder 4 inches high; copper bolt stamped "861" (recovered by U. S. Coast and Geodetic Survey)-----	861.721
Arlington, center of Southern California Railway station park; iron post stamped "814" (recovered by U. S. Coast and Geodetic Survey)-----	815.249

RIVERSIDE, EAST TO BOX SPRINGS; THENCE NORTH TO HIGH GROVE.

	Feet.
Riverside, Gage canal at Eighth street, in concrete bulkhead north of bridge; copper bolt stamped "1019"-----	1, 019. 821
Box Springs station, near crossing of Box Springs road and railroad, 65 feet west of track, 30 feet west of road; iron post stamped "1539"-----	1, 540. 064

BOX SPRINGS, SOUTH ALONG SOUTHERN CALIFORNIA RAILROAD, TO VALVERDE.

Valverde, east wall of brick warehouse, 4.5 feet above ground; copper bolt stamped "1509"-----	1, 509. 870
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AT TEMESCAL.

Temescal, southwest corner of district school grounds; iron post stamped "1114"-----	1, 114. 432
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ARLINGTON, SOUTHEAST TO EL SOBRANTE; THENCE EAST TO NEAR VALVERDE.

Mocking Bird Canyon, south of boulder dam (natural), on Hogback 50 feet south of road; iron post stamped "1219"-----	1, 219. 536
El Sobrante, 75 feet northeast of crossing of Gavilan mine and tin-mine roads; iron post stamped "1447"-----	1, 447. 823
North Mount Glen, center of sec. 10, T. 4 S., R. 4 W., in northwest corner of school grounds and at southeast corner of crossing of Elsinore and Corona roads; iron posts stamped "1651"-----	1, 652. 047

ELSINORE 30' QUADRANGLE.

VALVERDE, ALONG SOUTHERN CALIFORNIA RAILROAD TO PERRIS; THENCE SOUTHWEST TO ELSINORE.

Perris, Santa Fe station, south wall of brick corridor; bronze tablet stamped "1456"-----	1, 456. 697
Canyon siding, 4.5 miles south of Perris, 30 feet north of road where it leaves canyon and crosses over hills to west; iron post stamped "1399"-----	1, 399. 860
Menifee road, east of bridge over San Jacinto River and east of railroad track on south side of road; iron post stamped "1318"-----	1, 318. 740
Elsinore, Consolidated Bank Building, in brickwork on right side of corner entrance; bronze tablet stamped "1305"-----	1, 305. 753

ELSINORE, NORTHWEST ALONG SOUTHERN CALIFORNIA RAILROAD AND HIGHWAY, TO TEMESCAL.

Terra Cotta, 1 mile east of, east of road forks, 3.5 miles northwest of Elsinore; iron post stamped "1258"-----	1, 258. 346
T. 5 S., R. 5 W., sec. 7, 3 feet east of quarter-section post of, secs. 7 and 12, north of Temescal road; iron post stamped "1142"-----	1, 143. 144

NEAR VALVERDE, EAST TO PERRIS INDIAN SCHOOL.

Perris Indian School, east side of sec. 7, T. 4 S., R. 3 E., in brick balcony south side of steps at southwest entrance to main building; copper bolt stamped "1456"-----	1, 457. 173
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BOX SPRINGS, EAST ALONG ROAD, TO MORENO; THENCE SOUTH TO LAKE VIEW; THENCE SOUTHWEST, ALONG SOUTHERN CALIFORNIA RAILROAD, TO PERRIS.

Box Springs, north of siding, 65 feet west of Southern California Railway track and 30 feet west of road, at crossing of Box Springs road and railroad; iron post stamped "1539"-----	1, 540. 064
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	Feet.
Alessandro boulevard and Heacock street, at northeast corner of street, T. 3 S., between Rs. 3 and 4 W.; iron post stamped "1565"-----	1, 565. 452
Moreno, in front wall of brick store, southeast corner of streets; bronze tablet stamped "1600"-----	1, 600. 596
Lake Bottom road, 50 feet west of, in granite bowlder 2 feet high, 12 by 5 feet, at east point of hill 3 miles north of Lakeview; copper bolt stamped "1430"-----	1, 430. 770
Lakeview, northeast angle of lawn, public school grounds; iron post stamped "1468"-----	1, 468. 823

LAKEVIEW, SOUTHEAST ALONG ROAD, TO CASA LOMA.

Casa Loma ranch, at northeast fence corner, San Jacinto road and line between Rs. 1 and 2 W., T. 4 S.; iron post stamped "1466"----	1, 466. 594
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FERRIS, SOUTHEAST ALONG SOUTHERN CALIFORNIA RAILROAD (SAN JACINTO DIVISION), TO WINCHESTER; THENCE NORTHEAST ALONG SAME TO HEMET.

Benedict school, northeast corner of grounds and northeast corner of sec. 24, T. 5 S., R. 3 W.; iron post stamped "1500"-----	1, 500. 436
Winchester, east of front entrance of public school building; bronze tablet stamped "1470"-----	1, 470. 6
Egan siding, 1 mile southwest of, on line between Rs. 1 and 2 W., T. 5 S., north line of right of way; iron post stamped "1502"----	1, 503. 249

ELSINORE, SOUTHEAST ALONG SOUTHERN CALIFORNIA RAILROAD, TO TEMECULA.

Wildomar, corner Main street and Murrieta road, in angle of L-shaped schoolhouse grounds; iron post stamped "1254"-----	1, 254. 733
Murrieta, in southwest corner of public school grounds; iron post stamped "1092"-----	1, 092. 966

TEMECULA, NORTH ALONG ROAD, TO WINCHESTER.

T. 7 S., R. 3 W., near range line east of sec. 13, top of grade; iron post stamped "1309"-----	1, 309. 586
Alamos district school grounds, east side sec. 5, T. 7 S., R. 2 W., 35 feet east of building; iron post stamped "1375"-----	1, 376. 007
T. 6 S., R. 2 W., sec. 28, 335 feet north of bridge; iron post stamped "1419"-----	1, 419. 516
T. 6 S., R. 2 W., northwest corner sec. 10, Domenigoni Valley, 2.5 miles south of Winchester, at southeast corner of fence, road to Hemet; iron post stamped "1458"-----	1, 458. 454

SAN JACINTO QUADRANGLE.^a

SAN JACINTO, SOUTH ALONG SOUTHERN CALIFORNIA RAILWAY, TO HEMET.

San Jacinto, north side of east entrance of public school building; bronze tablet stamped "1562"-----	1, 562. 463
Hemet grammar school, in brick column on north side of steps; bronze tablet stamped "1591"-----	1, 591. 827

^a For additional elevations on this quadrangle refer to Farmer's double-primary line, Colton to Yuma, along Southern Pacific Railway, p. 30.

HEMET, SOUTHEAST ALONG ROAD, TO KENWORTHY.

	Feet.
Vallevista, southwest corner of school grounds; iron post stamped "1765"-----	1, 765. 817
T. 5 S., R. 2 E., sec. 18, range line on west side of section, top of knoll 20 feet south of road and east of bridge; iron post stamped "2062"-----	2, 062. 771
T. 5 S., R. 2 E., sec. 27, near mouth of Strawberry Creek, 125 feet from east side of road, in granite bowlder; copper bolt stamped "2932"-----	2, 932. 732
T. 5 S., R. 2 E., sec. 25, near mouth of Johnson Creek, 170 feet north of bridge, east side of road, inside of angle in fence; iron post stamped "4443"-----	4, 443. 802
T. 5 S., R. 3 E., sec. 31, divide of Hemet Valley and San Jacinto drainage, 20 feet north of road; iron post stamped "4936"-----	4, 936. 765
T. 6 S., R. 3 E., sec. 10, Thomas's ranch, opposite and north of house, west of road at fence corner, on section line between sections 3 and 10; iron post stamped "4394"-----	4, 394. 718
T. 6 S., R. 3 E., sec. 25, Thomas's ranch, 10 feet east of south gate, where road forks to Kenworthy and Coahuila Valley; iron post stamped "4509"-----	4, 509. 751

KENWORTHY, SOUTHWEST ALONG ROAD, TO WILSON VALLEY.

Coahuila divide, 18 feet west of road; iron post stamped "4965"-----	4, 965. 988
T. 7 S., R. 3 E., sec. 21, Mission Indian Reservation, 20 feet west of north gate, on north side of road; iron post stamped "3836"-----	3, 836. 748
Coahuila Indian School, sec. 23, T. 7 S., R. 2 E., 3 feet north of the southwest corner of the chapel yard; iron post stamped "3635"-----	3, 635. 696
T. 8 S., R. 2 E., sec. 5, divide between Coahuila and Wilson valleys, 7 feet southeast of road; iron post stamped "3542"-----	3, 543. 057

WILSON VALLEY, NORTH ALONG ROAD VIA SAGE, TO HEMET.

T. 7 S., R. 1 E., sec. 20, Lewis Valley, east of road, 18 feet north of line fence between sections 20 and 29; iron post stamped "2130"-----	2, 130. 960
Sage post-office, east of, sec. 12, T. 7 S., R. 1 W., on east side of Coahuila road; iron post stamped "2283"-----	2, 283. 879
T. 6 S., R. 1 W., sec. 36, Sage divide, 10 feet east of road, 260 paces south of Hemet road; iron post stamped "2615"-----	2, 615. 855
T. 6 S., R. 1 W., sec. 4, Diamanta schoolhouse, in Diamond Valley, 0.5 mile west of county road, 20 feet east of entrance to building, in edge of lawn; iron post stamped "1626"-----	1, 626. 898

THREE MILES EAST OF BEAUMONT, NORTH TO SOUTHWEST CORNER SAN BERNARDINO FOREST RESERVE (DOUBLE-RODDED LINE).

Ts. 2 and 3 S., Rs. 1 E. and 1 W., common corner, at southwest corner of San Bernardino Forest Reserve, 1.5 miles north of railroad, 2 feet south of Forest Reserve monument, which is an iron pipe filled with concrete on San Bernardino meridian; iron post stamped "2710"-----	2, 710. 700
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THREE MILES EAST OF BANNING, NORTH TO TOWNSHIP AND RANGE LINE CORNER (DOUBLE-RODDED LINE).

Ts. 2 and 3 S., Rs. 1 and 2 E., common corner, on south line of San Bernardino Forest Reserve, 1.25 miles north of Southern Pacific Railroad, in top of square iron post filled with concrete; copper bolt stamped "2342"-----	2, 342. 234
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FROM 3.6 MILES EAST OF CABEZON, NORTH TO TOWNSHIP AND RANGE LINE CORNER (DOUBLE-RODDED LINE).

	Feet.
Ts. 2 and 3 S., Rs. 2 and 3 E., common corner, 2 feet north of San Bernardino Forest Reserve, 1.7 miles north of Southern Pacific Railroad; iron post stamped "1978" -----	1,978.563
WHITEWATER, SOUTHEAST ALONG ROAD, TO PALM SPRINGS; THENCE SOUTH UP PALM CANYON TRAIL, TO VANDEVENTER; THENCE NORTHWEST TO KENWORTHY.	
T. 3 S., R. 4 E., sec. 29, 2.5 miles southeast of trestle 584 F, 25 feet east of rocky point, 5 feet south of Rubble canal from Whitewater River to Palm Springs; iron post stamped "828" -----	828.681
Palm Springs, in south concrete wall hotel building; bronze tablet stamped "455" -----	455.833
Garden of Eden, on township line between Ts. 4 and 5 S., R. 4 E., east of Palm Canyon road; iron post stamped "557" -----	557.878
Garden of Eden, 3 miles south of, east side of Palm Canyon, in a grove of palms on southwest side of small canyon, side of trail; iron post stamped "1000" -----	1,000.720
Garden of Eden, 10 miles south of, in Palm Canyon, near rocky gorge, by west wall of canyon, 100 feet southwest of creek crossing, where trail leaves the main canyon and crosses hills to the east; iron post stamped "3000" -----	3,000.032
Vandeventer, north of house on a little knoll, in a granite boulder 3 feet high, 8 by 4 feet, 50 feet east of road to house just south of where it forks to Kenworthy; copper bolt stamped "4549" -----	4,549.646
Kenworthy, south of post-office, in a granite boulder 3 feet high, 7 by 5 feet, at rocky point 100 feet north of wash, by trail; bolt stamped "4566" -----	4,566.491

INDIO SPECIAL QUADRANGLE.^a

WALTERS, WEST, VIA MARTINEZ, TO TORO; THENCE NORTH TO INDIO.

Walters, 27 feet northwest of station, in corner of yard; iron post stamped "—189 T" (below sea level) -----	—188.341
Martinez Indian school, 40 feet southeast of, at northeast side of entrance to yard; iron post stamped "—135 T" -----	—134.114
Toro Indian Village, north side of, in northeast angle of intersection of road north to Indio with road east and west; iron post stamped "—111 T" -----	—110.122
Indio, 4.7 miles south of, sec. 12, T. 5 S., R. 7 E., at south side quarter corner; iron post stamped "—62 T" -----	— 61.125

INDIO, WESTERLY, VIA WHITEWATER RIVER ROAD, TO PALMDALE.

Indian Well, 70 feet south of; iron post stamped "97 T" -----	97.744
Indian Well, 3.9 miles northwest of, sec. 17, T. 5 S., R. 6 E., 6 feet south of road; iron post stamped "181 T" -----	181.549
Indian Well, 7.12 miles northwest of, sec. 12, T. 5 S., R. 5 E., 7 feet north of road and 25 feet north of spur of mountain; iron post stamped "230 T" -----	230.757
Palm Springs, 4.33 miles southeast of, sec. 29, T. 4 S., R. 5 E., 12 feet south of road, at point of mountain; iron post stamped "323 T" --	323.654

^a For additional elevations on this quadrangle refer to Farmer's double primary line, Colton to Yuma, along Southern Pacific Railway, p. 30.

VANDEVENTER, EAST ALONG TRAIL AND MARTINEZ CANYON, TO MARTINEZ.

	Feet.
Vandeventer, 4 miles northeast of, 3 feet north of north bank of sand wash, 165 feet southwest of point where trail to Martinez leaves wash, in face of white ledge 2.5 by 3 by 2.5 feet; bronze tablet stamped "3871 T"-----	3, 871. 854
Deep Canyon, 40 feet west of edge of west bluff, 15 feet north of trail, in top of granite boulder 4.5 by 5 by 3 feet; bronze tablet stamped "3492 T"-----	3, 492. 906
Summit of divide between Deep and Martinez canyons, on west slope of Martinez Mountain, 25 feet northeast of trail, in southeast face of granite boulder 4 by 5 by 6 feet; bronze tablet stamped "5168 T"-----	5, 168. 832
Agua Alta Spring, 235 feet southwest of, on northeast side of trail, 70 feet northwest of sand wash, on northwest side of granite boulder 3.5 by 5 by 6 feet; bronze tablet stamped "4282 T"-----	4, 282. 623
Martinez Canyon, south side of, opposite mouth of Casa de Tahquitz Canyon, 420 feet from foot of steep side of trail, in top of flat granite boulder 2 by 8 by 9 feet; bronze tablet stamped "2537 T"-----	2, 537. 378
Martinez Canyon, 270 feet below junction with Black Canyon, in face of granite cliff on south side of wash; bronze tablet stamped "1584 T"-----	1, 584. 808
Martinez Canyon, north side of, at mouth, 5 miles southwest of Martinez Indian school, in face of granite cliff 4 feet above ground; bronze tablet stamped "655 T"-----	655. 841

WALTERS, SOUTH ALONG ROAD, TO SOUTH SIDE SEC. 26, T. 9 S., R. 9 E.

Alamo Bonito, south side of, near water hole, in triangle between roads; iron post stamped "—186 T"-----	—185. 201
Agua Dulce, at north end of Indian Village, 300 feet south of spring and garden, in road forks; iron post stamped "—183 T"-----	—182. 286
Figtrée John, 140 feet southwest of reservoir at spring, 5 feet west of road, opposite fence corner; iron post stamped "—196 T"-----	—196. 250
Fish Spring, 1.12 miles south of, 6 feet east of road; iron post stamped "—233 T"-----	—232. 178
T. 9 S., R. 9 E., sec. 26, south side of section, 4.12 miles southeast of Fish Spring, 7 feet east of road; iron post stamped "—175 T"-----	—174. 116

AT SEVENTEEN PALMS (SOUTH SIDE SEC. 35, T. 10 S., R. 8 E.)

Seventeen Palms, 165 feet south of chimney, on west side of road; iron post stamped "410 T"-----	410. 828
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SALTON QUADRANGLE.²

SEC. 26, T. 9 S., R. 9 E., SOUTH TO CLAY POINT.

T. 10 S., R. 9 E., quarter corner south side of sec. 12; iron post stamped "—39 T" (below sea level)-----	—38. 128
Clay Point, in forks of road at junction with road to water holes; iron post stamped "36 T"-----	36. 846

² For additional elevations on this quadrangle refer to Farmer's double primary line, Colton to Yuma, along Southern Pacific Railway, p. 31.

CLARK LAKE QUADRANGLE.

CLAY POINT, SOUTHWEST ALONG TRAIL AND NORTHWEST, TO SEVENTEEN PALMS.

	Feet.
T. 11 S., R. 9 E., southeast corner of sec. 4; iron post stamped "71 T"-----	71.904

SEVENTEEN PALMS, SOUTHWEST ALONG TRAIL TO BOREGO SPRINGS.

Seventeen Palms, 3.2 miles southwest of, 8 feet east of road; iron post stamped "367 T"-----	367.889
T. 11 S., R. 7 E., northeast corner of sec. 24; iron post stamped "336 T"-----	336.779
Borego Springs, 60 feet south of, 25 feet north of cabin; iron post stamped "452 T"-----	452.906

SAN LUIS REY 30' QUADRANGLE.

TEMECULA, ALONG ROAD SOUTH VIA RAINBOW TO SEC. 31, T. 10 S., R. 3 W. (DOUBLE-RODDED LINE.)

Temecula, in west foundation wall of schoolhouse; bronze tablet stamped "1019"-----	1,019.651
Temecula, 3.75 miles southeast of, east side of road, in north face of granite boulder 18 feet high and 12 feet broad; copper bolt stamped "U. S. G. S. 1155 Ft."-----	1,155.785
Rainbow post-office, 1.5 miles north of, on west side of Temecula road, in south end of boulder 2.5 feet high, 15 feet long, and 5 feet wide, under a double oak tree in fence line; copper bolt stamped "U. S. G. S. 1164 ft. B. M."-----	1,164.781
Rainbow, at northeast corner of Vallecitos schoolhouse grounds; iron post stamped "1044"-----	1,044.696
T. 10 S., R. 2 W., northwest corner, 200 feet south of oak tree on west side of Rainbow-Bonsall road at junction with Palla road; iron post stamped "290"-----	290.735
San Luis Rey River, north bank of, on north side of Bonsall-Palla road, in granite boulder; copper bolt stamped "U. S. G. S. 274 Ft. B. M."-----	274.860
Bonsall, in center of street north of post-office, in top of boulder 12 feet in diameter, 6 feet high; copper bolt stamped "U. S. G. S. 172 Ft. B. M."-----	172.821
Bonsall, 2.25 miles south of, at junction of Vista and Oceanside roads, near fence corner; iron post stamped "155"-----	155.873
SPUR FROM 2 MILES EAST OF SAN LUIS REY, NORTH TO SOUTHWEST CORNER SEC. 34, T. 10 S., R. 4 W.	

T. 10 S., R. 4 W., southwest corner of sec. 34, 24 feet northeast of forks of road; iron post stamped "112 T"-----	112.714
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TEMECULA, EAST UP TEMECULA RIVER, TO VICINITY OF PAUBA GRANT.

Pauba ranch house, 0.25 mile south of, northeast of forks of road; iron post stamped "1090 T"-----	1,090.773
Temecula, 6.5 miles east of irrigating ditch and double fork road, north of road; iron post stamped "1161 T"-----	1,161.702
Temecula, 8.5 miles east of, southeast corner of private road crossing, just west of dry wash of Temecula River; iron post stamped "1228 T"-----	1,228.775

PRIMARY LEVELING.

59

MONSERATE SCHOOL, EAST VIA PALA, TO VICINITY OF PAUMA RANCH.

	Feet.
Mouserate schoolhouse, 2 feet south of, under window; iron post stamped "351 T"-----	351.728
Pala, 10 feet south of southwest corner of mission; iron post stamped "411 T"-----	411.674
Pala, 1.75 miles east of, at fork of road to Aqua Tibia ranch, north-east of road; iron post stamped "568 T"-----	569.030
Pala, 3 miles east of, fork of road to Pala Mills, north of road; iron post stamped "557 T"-----	557.729
Pauma ranch, southeast of fork of road to ranch house; iron post stamped "758 T"-----	758.708

SPUR SOUTH FROM PALA 2 MILES.

Pala, 2 miles south of, northeast of forks of road; iron post stamped "481 T"-----	481.799
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NEAR OUTING, SOUTHWEST TO DELUZ; THENCE SOUTH TO DELUZ STATION.

Sandia Canyon, in forks of Linda Rosa and Fallbrook road and road to Deluz; iron post stamped "837 T"-----	837.422
Deluz, 1.25 miles south of, 30 feet west of forks of road to school-house (Deluz), in bed rock; copper bolt stamped "379 T"-----	379.909
Deluz Station, 12 feet northwest of switch south of; iron post stamped "146 T"-----	146.825

RAINBOW, WEST VIA FALLBROOK, TO DELUZ STATION.

Red Mountain ranch, just east of, northwest of forks of road; iron post stamped "1063 T"-----	1,063.660
Fallbrook, 50 feet north of schoolhouse, south side of Elder street; iron post stamped "732 T"-----	732.660

DELUZ STATION, SOUTH ALONG SOUTHERN CALIFORNIA RAILROAD, TO YSIDORA; THENCE WEST TO LAS FLORES.

Santa Margarita ranch house, southwest corner of retaining wall around, in middle pin; bronze tablet stamped "87 T"-----	87.657
Ysidora, 40 feet east of track, north side of road at fence corner; iron post stamped "23 T"-----	23.579
Ysidora, 1.5 miles west of, north of road at summit; iron post stamped "411 T"-----	411.696
Las Flores, 10 feet southwest of water tank, east of track; iron post stamped "84 T (S. B (?))" (recovered by U. S. Coast and Geodetic Survey) -----	84.744

LAS FLORES, NORTHEAST UP LAS PULGAS CANYON, TO LAS PULGAS CORRAL.

Las Pulgas corral, 0.5 mile northeast of, east side of Las Flores Creek, on side of hill; iron post stamped "293 T"-----	293.652
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ESCONDIDO 15' QUADRANGLE (SAN LUIS REY 30' QUADRANGLE).

BONSALL, SOUTHEAST TO MOOSA.

Moosa, 15 feet southwest of house next east of post-office; iron post stamped "458 T"-----	458.821
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NEAR BONSALL, SOUTH TO VISTA; THENCE SOUTHEAST, ALONG SOUTHERN CALIFORNIA RAILROAD AND COUNTY ROAD, TO GREEN VALLEY (DOUBLE-RODDED LINE).

	Feet.
Delphi, northwest corner of schoolhouse grounds; iron post stamped "491"-----	491.806
Vista, 50 feet northeast of Escondido Branch Railroad track, on southwest side of county road, in row of eucalyptus trees east of railroad crossing; iron post stamped "330"-----	330.870
San Marcos, close to schoolhouse building, in angle of porch and building in front; iron post stamped "582"-----	582.826
Richland, in row of eucalyptus trees at southern corner of school grounds, 50 feet northeast of track and 35 feet northwest of road center; iron post stamped "634."-----	634.920
Escondido, northeast corner of iron footplate of step at entrance to drug store, on lot 15, next to bank and post-office building, on Main street; official city bench mark-----	654.661
Escondido, in north wall of main entrance to corridor in basement of college building on hill, 4 feet above ground; bronze tablet stamped "754"-----	754.948
Escondido, 2.5 miles south of, on San Diego road at junction; iron post stamped "530"-----	530.959
Bernardo post-office, 625 feet north of Bernardo River bridge, on west side of county road; iron post stamped "319"-----	319.983
Green Valley, in sloping boulder 4 feet high, east of large boulder pile, west side of San Diego road and 80 feet north of bridge; copper bolt stamped "U. S. G. S. 482 ft. B.M."-----	482.976

BERNARDO, NORTHEAST ALONG RIVER ROAD, TO SAN PASQUAL.

Glenella schoolhouse, 80 feet southwest of, in yard; iron post stamped "381 T"-----	381.763
San Pasqual schoolhouse, in yard at east side of gate; iron post stamped "366 T"-----	366.791

OCEANSIDE 15' QUADRANGLE (SAN LUIS REY 30' QUADRANGLE).

YSIDORA, SOUTHEAST TO SAN LUIS REY; THENCE NORTHEAST TO NEAR BONSALL.

San Luis Rey, northeast corner of grounds around schoolhouse; iron post stamped "76 T"-----	76.579
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RAMONA QUADRANGLE.

AT WILSON VALLEY.

T. 8 S., R. 1 E., about southwest corner sec. 2 in Wilson Valley, 4 feet east of lowest point of road; iron post stamped "2146"-----	2,146.866
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PAUBA GRANT, SOUTHEAST VIA OAK GROVE, TO WARNER RANCH.

Nigger Canyon, 1.75 miles southeast of, 10 feet south of road, at junction of Temecula-Warner road with road to north, 120 feet southwest of box elder tree; iron post stamped "1450 T"-----	1,450.683
Radec post-office, 0.25 mile north of, at junction with road to San Jacinto; iron post stamped "1694 T"-----	1,694.668
Cienega schoolhouse, 2 feet south of fence and 3 feet east of front gate; iron post stamped "1988 T"-----	1,988.615

	Feet.
Cienega schoolhouse, 2.75 miles southeast of, in flat draw, 10 feet north of road; iron post stamped "2439 T"-----	2, 439. 679
Oak Grove schoolhouse, 50 feet south of, in yard, at east side of gate; iron post stamped "2751 T"-----	2, 751. 637
Oak Grove schoolhouse, 4 miles southeast of, sec. 35, T. 9 S., R. 2 E., about 400 feet west of quarter corner, 10 feet west of road on summit of divide between Temecula and San Luis Rey rivers, 3 feet east of fence corner; iron post stamped "3282 T"-----	3, 282. 746
Puerta Cruz, 0.5 mile northeast of, 25 feet south of road; iron post stamped "2916 T"-----	2, 916. 746
Warner's ranch, 0.5 mile northeast of Adobe Cabin corral, north side of Agua Caliente Creek bed, in southeast corner of intersection of road from ranch house to corral with Temecula-Julian road; iron post stamped "2772 T"-----	2, 772. 733

WARNER'S RANCH, WEST VIA SAN LUIS REY CANYON AND POTRERO INDIAN RESERVATION, TO PAUMA GRANT.

San Luis Rey Canyon, head of, 45 feet west of road above foot of grade in first bend of Smith Mountain; iron post stamped "2724 T"-----	2, 724. 628
Amago post-office, 3.33 miles southeast of, at east side of trail in San Luis Rey Canyon, south side of creek, 100 feet west of junction of dry creek bed from south with San Luis Rey River, on west side of granite ledge; bronze tablet stamped "2404 T"-----	2, 404. 694
Lajolla, at southwest corner of, Indian reservation schoolhouse; iron post stamped "2719 T"-----	2, 719. 777
Sparkman's store, 45 feet northwest of, 2 feet northeast of stone fence on southwest side of road; iron post stamped "1016 T"-----	1, 016. 622

SPARKMAN'S STORE, SOUTH VIA RINCON, TO T. 11 S., R. 1 W.

Rincon schoolhouse, 1.87 miles south of, 0.5 mile south of San Luis Rey River crossing, at junction of road to Escondido with road up creek; iron post stamped "939 T"-----	939. 583
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ADOBE CABIN CORRAL ON WARNER'S RANCH, EAST TO AGUA CALIENTE; THENCE SOUTHEAST TO POINT 1 MILE EAST OF WARNER SCHOOLHOUSE; THENCE NORTHWEST TO ADOBE CABIN CORRAL.

Agua Caliente schoolhouse, southwest corner of; iron post stamped "3165 T"-----	3, 165. 634
Warner schoolhouse, 3.25 miles north of, T. 10 S., R. 3 E., 150 feet east of road and 5 feet east of southwest corner of building; iron post stamped "3459 T"-----	3, 459. 682
Warner schoolhouse, 1 mile east of, 50 feet east of junction of old Fort Yuma road with road to east; iron post stamped "3240 T"-----	3, 240. 601
Warner ranch house, in forks of road at southwest corner of; iron post stamped "2894 T"-----	2, 894. 681

HEAD OF SAN LUIS REY CANYON, SOUTHEAST TO SANTA YSABEL; THENCE WEST, VIA RAMONA, TO SAN PASQUAL.

Mesa Grande road, 400 feet southwest of end of lane; iron post stamped "2719 T"-----	2, 719. 614
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	Feet.
T. 11 S., R. 3 E., north side of sec. 32, Santa Ysabel ranch boundary line, 5 feet south of intersection with section line; iron post stamped "3015 T"-----	3, 015. 636
Balcon Canyon, in forks of road; iron post stamped "3123 T"-----	3, 123. 792
Santa Ysabel, 180 feet west of road junction and south side of road; iron post stamped "2983 T"-----	2, 983. 684
Santa Ysabel schoolhouse, in yard at north side of gate; iron post stamped "2764 T"-----	2, 764. 738
Ballena schoolhouse, 60 feet south of, in yard at east side of gate; iron post stamped "2470 T"-----	2, 470. 640
Mesa Grande, in forks of road; iron post stamped "1776 T"-----	1, 776. 729
Ramona town hall, east side of, 0.5 foot above step; aluminum tablet stamped "1440 T"-----	1, 440. 697
Pamo grade, 0.2 mile south of forks of road, west of road, in turntable; iron post stamped "789 T"-----	789. 624
East San Pasqual, 1 mile east of, 95 feet north of schoolhouse, in yard, 3 feet from fence at west side of gate; iron post stamped "410 T"-----	410. 636

JUNCTION OF ROAD 3 MILES EAST OF RAMONA, NORTH TO SPRING HILL SCHOOLHOUSE.

T. 12 S., R. 2 E., sec. 32, Spring Hill schoolhouse, 55 feet west of, in yard at south side of gate; iron post stamped "2340 T"-----	2, 340. 666
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SAN YSABEL, EAST TO JULIAN; THENCE NORTH TO OBERLIN SCHOOLHOUSE.*

Wynola, at northeast corner of road intersection; iron post stamped "3654 T"-----	3, 654. 600
Julian, 1.75 miles west of, at southwest corner of junction of main road with private road to south; iron post stamped "3948 T"-----	3, 948. 690
Julian high schoolhouse, in yard at north side of gate; iron post stamped "4219 T"-----	4, 219. 765
Oberlin schoolhouse, in yard at north side of gate; iron post stamped "4132 T"-----	4, 132. 471

CUCAMONGA, DEEP CREEK, HESPERIA, POMONA, ROCK CREEK, SAN ANTONIO, SAN BERNARDINO AND VICTOR 15' QUADRANGLES; SAN GORGONIO 30' QUADRANGLE.

LOS ANGELES AND SAN BERNARDINO COUNTIES.

The elevations in the following list are based upon the 1906 precise-level line of the United States Coast and Geodetic Survey from San Diego which recovered several bench marks of this list on San Bernardino, Hesperia, and Victor quadrangles.

The leveling of Pomona, Cucamonga, and on part of San Bernardino quadrangles was done in 1897 by Mr. H. S. Crowe, levelman; other leveling was done on San Bernardino, Hesperia, and Victor quadrangles in 1898; on Hesperia, Victor, and Deep Creek quadrangles in 1898-99, and on San Antonio and Rock Creek quadrangles in 1899, under Mr. W. T. Turner, topographer, by Mr. C. R. Smith,

* A line from south closes 1.6 feet high on Julian.

levelman. The leveling on San Gorgonio quadrangle was done in 1899 under Mr. E. T. Perkins, topographer, by Messrs. C. R. Smith, R. A. Hamilton, and C. C. Ward, levelmen.

POMONA QUADRANGLE.

BASSETT, EAST ALONG SOUTHERN PACIFIC RAILROAD, TO POMONA (DOUBLE-RODDED LINE).

	Feet:
Bassett, 86.7 feet from west end of platform and 107.7 feet south of southwest corner of station; iron post stamped "295"-----	295.540
Puente, 18 feet west of turnstile in fence north of station, 125 feet north of east end of platform; iron post stamped "328"-----	328.659
Puente warehouse, 1.4 feet from northwest corner and 1.2 feet below brick foundation; bronze tablet stamped "331"-----	331.745
Lemon, in southeast corner of fence of railroad reservation and 113.2 feet from southwest corner of station; iron post stamped "519"---	519.879
Spadra, 122.4 feet from northwest corner of station; iron post stamped "711"-----	711.998
Pomona, 55 feet from station, near telegraph pole near park hedge; iron post stamped "861"-----	861.738
Pomona, in Odd Fellows Building, corner Second and Ellen streets, on Ellen street side, 11.6 feet from Second street corner, in third course from window and 8.5 courses from sidewalk; bronze tablet stamped "854"-----	855.069

CUCAMONGA QUADRANGLE.

POMONA, EAST ALONG SOUTHERN PACIFIC RAILROAD, TO SOUTH ETIWANDA (DOUBLE-RODDED LINE).

Pomona, J. H. Graber building, corner railroad reservation and Gordon street, northwest corner of Gordon street, four rows from corner, 7 courses from sidewalk; bronze tablet stamped "861"-----	861.992
Ontario, in grass plot in front of station, 79.2 feet south of southwest corner of station; iron post stamped "986"-----	986.375
Ontario, in southwest corner of Southern Pacific Hotel, seventh course from sidewalk and two courses from doorway on west side of building; bronze tablet stamped "992"-----	992.315
Ontario, in northwest corner of bank building, on Main avenue, second corner from steps, eighth course above sidewalk; bronze tablet stamped "987"-----	987.830
South Cucamonga (Zucker), in station park, 45.1 feet from southeast corner of station and 2.6 feet from telegraph pole; iron post stamped "958"-----	958.556
South Etiwanda, 58.6 feet south of center of wagon road and 2.6 feet west of telegraph pole; iron post stamped "981"-----	982.134

SAN BERNARDINO QUADRANGLE.

RIVERSIDE, NORTHEAST TO HIGH GROVE.

High Grove, station park south end of diamond-shaped lawn; iron post stamped "945" (recovered by U. S. Coast and Geodetic Survey)-----	945.517
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RIVERSIDE, NORTHEAST ALONG MOTOR RAILROAD, TO SAN BERNARDINO; THENCE NORTHWEST
ALONG ATCHISON, TOPEKA AND SANTA FE RAILROAD, TO KEENBROOK.

	Feet.
Colton, 1 mile northeast of, at Lytle Creek, in northeast cylinder on east side of wagon-road bridge; copper bolt stamped "1007"-----	1, 007. 486
San Bernardino, in stone on northeast corner of court-house building; bronze tablet stamped "1048" (recovered by U. S. Coast and Geodetic Survey)-----	1, 048. 451
Verdemont, 2.8 miles southward from, 50 feet east of track at point where 3 wagon roads pass over one common crossing; iron post stamped "1420 S B" (recovered by U. S. Coast and Geodetic Survey)-----	1, 420. 770
Glen Helen ranch, on east side of county road; iron post stamped "2008 S B" (recovered by U. S. Coast and Geodetic Survey)-----	2, 009. 267

SOUTH ETIWANDA, EAST ALONG SOUTHERN PACIFIC RAILROAD, TO MOUND CITY (DOUBLE-RODDED LINE).

San Sevaine, on south side of track, 231 feet from southwest corner of station, near fence; iron post stamped "1063"-----	1, 063. 238
Bloomington, south side of track, 87.9 feet from southeast corner of station, 2.2 feet from telegraph pole and 7 feet from center of wagon road; iron post stamped "1090"-----	1, 090. 279
Bloomington, in brick building at post-office, in sixth course of brick above foundation and second course from southeast corner of building owned and occupied by W. H. H. Easton, southwest corner of Orchard and Commercial streets; bronze tablet stamped "1098"-----	1, 099. 141
Colton, 1.25 miles west of, at Cement Company's storehouse, in wall on north side, 3.4 feet from east corner, 0.7 foot from top of foundation, 35.8 feet from center of track; bronze tablet stamped "1006"-----	1, 006. 663
Colton, in corner of brick building at Transcontinental Hotel, in third course above top of corner post and in center of brick laid horizontally; bronze tablet stamped "978"-----	979. 073

COLTON, EAST ALONG SOUTHERN PACIFIC RAILROAD, TO VICINITY OF PALM SPRINGS.

Mound City, northeast corner of reservoir wall east of station; copper bolt stamped "1079"-----	1, 079. 762
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ROCK CREEK QUADRANGLE.^a

NORTH SIDE SEC. 4, T. 4 N., R. 8 W., WEST TO ROCK CREEK; THENCE SOUTHEAST TO SHOEMAKER (BIG ROCK VILLA).

Sheep Creek, 14.5 miles west of, at forks where second road to Palm-dale branches to northwest; iron post stamped "3497 S B"-----	3, 497. 687
Shoemaker's ranch, on Rock Creek, 50 feet west of hotel; iron post stamped "3927 S B"-----	3, 927. 355

SAN ANTONIO QUADRANGLE.

APPLEWHITE, NORTHWEST VIA NORTH FORK OF LITTLE CREEK AND LONE PINE CANYON ROADS, TO CENTER OF T. 3 N., R. 7 W.; THENCE NORTH AND EAST ALONG SHEEP CREEK ROAD, TO TAMBORINO (10 MILES WEST OF HESPERIA).

Glen (Applewhite) ranch, 5.45 miles northwest of, at mouth of Cold-water Canyon, near first pine tree above forks of road; iron post stamped "5017 S B"-----	5, 017. 766
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^a These elevations are possibly in error on account of closure on line from southeast about 3 feet high.

	Feet.
Hesperia, 24.65 miles southwest of, at forks where Swartout road branches off to the west, north side of road; iron post stamped "6006 S B"-----	6,006.428
Hesperia, 19.35 miles southwest of, at forks where main traveled road branches off to northwest to Palmdale and Lancaster, west side of road; iron post stamped "4420 S B"-----	4,420.322
Hesperia, 10 miles west of, south side of road at the Tamborino ranch; iron post stamped "3740 S B"-----	3,740.127
MOUTH OF SHEEP CREEK, NORTHWEST ALONG LANCASTER AND PALMDALE ROAD, TO SEC. 4, T. 4 N., R. 8 W.	
Sheep Creek, 8 miles west of, in front of deserted frame dwelling house on south side of road; iron post stamped "3763 S B" (possibly 3 feet too high)-----	3,763.393

SHEEP CREEK SUMMIT, WEST UP SWARTOUT VALLEY, TO SHOEMAKER.

Swartout road summit, on south side of road in gap; iron post stamped "6862 S B" (true elevation is possibly 3 feet higher)----	6,862.311
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HESPERIA QUADRANGLE.

KEENBROOK, NORTHEAST ALONG ATCHISON, TOPEKA AND SANTA FE RAILROAD, TO VICTOR.

Cosy Dell road station, inside of garden fence east of county road; iron post stamped "2768 S B"-----	2,768.147
Cajon, 4.75 miles north of, at point where county road recrosses railroad track, west side of track; iron post stamped "3685 S B"-----	3,684.985
Summit station, 5.2 miles north of, where second wagon road crosses railroad, 40 feet west of track and 20 feet north of wagon road; iron post stamped "3462 S B" (recovered by U. S. Coast and Geodetic Survey)-----	3,462.665
Hesperia, at northeast corner of red brick hotel building; iron post stamped "3190 S B" (recovered by U. S. Coast and Geodetic Survey)-----	3,190.475
Hesperia, 4.75 miles north of, cross on north end of coping of small cement culvert west side of track (recovered by U. S. Coast and Geodetic Survey)-----	2,856.822

HESPERIA, WEST ALONG ROAD, TO TAMBORINO RANCH; THENCE NORTHEAST, ALONG NORTH BRANCH OF SHEEP CREEK, TO POINT 5 MILES WEST OF VICTOR.

Hesperia, 5 miles west of, at junction of road to Tamborino ranch with road from Oro Grande to San Bernardino, via Cajon Pass; iron post stamped "3522 S B"-----	3,522.120
Hesperia, 10 miles west of, at southeast corner of Tamborino ranch, on south side of Sheep Creek road, 30 feet southeast of corner common to secs. 13, 14, 23, and 24, T. 4 N., R. 6 W.; iron post stamped "3740 S B"-----	3,740.127

KEENBROOK, NORTHWEST TO APPLEWHITE (GLEN) RANCH.

Applewhite (Glen) ranch, 40 feet west of westernmost building; iron post stamped "3256 S B"-----	3,256.940
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SUMMIT, EAST TO BURCHAM'S RANCH; THENCE SOUTHWEST ALONG CLEGHORN CANTON, TO COSY DELL.

	Feet.
Burcham's ranch, on east end of south side rail of large cattle scales; cross cut on iron plate-----	3, 181. 54
Ts. 2 and 3 N., Rs. 4 and 5 W., 400 feet south of common corner, on left side of road by gate in west fence of Wixum's ranch on West Fork of Mohave River; iron post stamped "3355 S B"-----	3, 354. 966

VICTOR QUADRANGLE.

VICTOR, WEST ALONG ROAD 5.2 MILES.

Victor, 60 feet north of wagon bridge over Mohave River and 60 feet west of track; iron post stamped "2723 S B" (recovered by U. S. Coast and Geodetic Survey)-----	2, 723. 292
Victor, south end of veranda of Turner Hotel; cross chiseled on west end of top stone step-----	2, 716. 77
Victor, 5.25 miles west of, at point where Oro Grande and San Ber- nardino road crosses road from Victor to Sheep Creek; iron post stamped "3063 S B"-----	3, 063. 594

DEEP CREEK QUADRANGLE.

VICTOR, SOUTHEAST ALONG OLD TELEGRAPH ROAD, TO FIFTEENMILE POINT.

Victor, 5.75 miles southeast of, on Rocksprings and Old Telephone Line roads, 6 feet right of latter road, on brow of second bench land; iron post stamped "2960 S B"-----	2, 959. 960
Fifteenmile Point, 0.5 mile east of where road from Victor joins old stage road from San Bernardino to Rabbit Springs; iron post stamped "3010 S B"-----	3, 010. 780

HESPERIA, EAST VIA BEAR VALLEY AND RABBIT SPRINGS ROAD, TO FIFTEENMILE POINT.

Mohave River, on brow of first bench land east of, 4 feet north of Bear Valley road; iron post stamped "3097 S B"-----	3, 097. 041
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JUNCTION OF RABBIT SPRINGS AND BEAR VALLEY ROADS, SOUTHEAST ALONG BEAR VALLEY ROAD TO COXEY'S RANCH; THENCE WEST DOWN DEEP CREEK, TO MOHAVE RIVER.

Rock Springs, in triangle of roads; iron post stamped "3748 SB"---	3, 748. 181
Coxey's ranch, in corner of garden fence; iron post stamped "5619 S B"-----	5, 619. 653
Deep Creek, Hesperia Land and Water Company's diversion dam; surface of top of cement work-----	3, 366. 54

HESPERIA, SOUTHEAST ALONG PIPE LINE, TO MOHAVE RIVER (SOUTHWEST CORNER, SEC. 7, T. 3 N., R. 3 W.); THENCE SOUTHWEST TO BURCHAM'S RANCH.

T. 3 N., R. 3 W., southwest corner sec. 7, 7 miles southeast of Hes- peria; iron post stamped "2960 S B"-----	2, 960. 131
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COXEY'S RANCH, SOUTHEAST 4.3 MILES, TO JUNCTION OF ROAD TO PINE FLATS.

Coxey's ranch, 4.3 miles southeast of, at point where road to Pine Flat branches off, in forks of road; iron post stamped "6823 SB"---	6, 823. 543
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PRIMARY LEVELING.

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SAN GORGONIO 30' QUADRANGLE.

FIFTEENMILE POINT, EAST TO BOX S RANCH (1 MILE SOUTHEAST OF RABBIT SPRINGS);
THENCE SOUTHEAST TO NEAR CACTUS SPRINGS; THENCE WEST, VIA HOLCOMB VALLEY, TO
POINT 4.3 MILES EAST OF COXEY'S RANCH.

	Feet.
Box S ranch, sec. 11, T. 4 N., R. 1 W., south side of section, in front of dwelling house; iron post stamped "2935 S B"-----	2,936.196
Box S Springs, sec. 4, T. 3 N., R. 1 E., northeast corner of section, 6.25 miles southeast of Box S ranch, at east end of watering trough; iron post stamped "3550 S B"-----	3,550.149
Cactus Flat, at northeast corner of picket fence in front of James Johnson's residence; + on embedded square stone monument-----	5,878.91
Cactus Flat, 1 mile southeast of, sec. 30, T. 3 N., R. 2 E., where road branches off to the south from road to Rose Mine; iron post stamped "6031 S B"-----	6,031.796
Holcomb Valley, sec. 31, T. 3 N., R. 1 E., in front of offices of Holcomb Valley Mining Company; iron post stamped "7239 SB"-----	7,240.028

HOLCOMB VALLEY, SOUTH 3 MILES, TO BEAR LAKE; THENCE WEST TO FAWNskin VALLEY;
THENCE NORTHEAST TO HOLCOMB VALLEY.

Holcomb Valley, 3.5 miles southeast of, where west branch of Poligue Canyon road joins Bear Valley road to San Bernardino; iron post stamped "6761 S B"-----	6,761.879
Fawnskin Valley, upper end of, where Holcomb Valley road forks to the northeast; iron post stamped "7211 S B"-----	7,211.964

BAIRDSTOWN (SOUTH OF CACTUS FLAT), SOUTHEAST VIA ROSE MINE, TO MOUND SPRINGS;
THENCE NORTH TO OLD WOMANS SPRINGS; THENCE SOUTHWEST TO CUSHENBERRY.

Baldwin Lake, 0.75 mile east of, at junction of road from Rose mine to Bear Valley with road to Bairdstown, in road forks; iron post stamped "6773 S B"-----	6,773.415
Rose mine, at southeast corner of cook house; iron post stamped "6867 S B"-----	6,867.597
Old Womans Springs, 3.5 miles south of, west side of road, 400 feet north of where it leaves Rattlesnake Canyon and runs north toward springs; iron post stamped "3659 S B"-----	3,659.745
Old Womans Springs, 40 feet south of house, 4 feet from cottonwood tree 1 foot in diameter; iron post stamped "3186 SB"-----	3,186.544
Old Womans Springs, 4.5 miles west of, on north of road, opposite junction of road with road to southeast, where road goes between two small hills; iron post stamped "3565 S B"-----	3,565.512

WHITewater STATION, NORTH VIA CHUCK WARREN'S, TO "THE PIPES;" THENCE NORTH-
WEST TO ROSE MINE.

Dry Morongo, about sec. 9, T. 2 S., R. 4 E., on west side of canyon at junction with Mission Creek Valley, 15 feet west of road junction; iron post stamped "1800 S B"-----	1,800.475
Warren's ranch, sec. 28, T. 1 S., R. 4 E., at gatepost, 110 feet south of barn; iron post stamped "2504 S B"-----	2,504.499
T. 1 S., R. 4 E., sec. 14, 100 feet southwest of northeast corner, in forks of Little Morongo Canyon road, where it branches from road to Virginia Dale; iron post stamped "2745 S B"-----	2,745.674

	Feet.
Little Morongo Canyon, sec. 2, T. 1 S., R. 4 E., mouth of lateral canyon, at junction with trail to The Pipes, at upper end of timber patch, 3 feet above ground, in face of granite cliff; aluminum tablet stamped "3380 S B"-----	3, 380.536
The Pipes, 20 feet northeast of house, 45 feet southwest of barn, 2 feet east of yucca tree; iron post stamped "4459 S B"-----	4, 459.430
Burns Spring, 1.75 miles northwest of, in saddle of small spur ridge, at top of first steep hill out of canyon; iron post stamped "5438 S B"-----	5, 438.270
Rattlesnake Canyon, 1.1 miles southeast of, at junction of road from The Pipes to Rose Mine with road to Old Womans Springs, 23 feet west of piñon tree; iron post stamped "5736 S B"-----	5, 736.444
WHITEWATER SIDING, NORTHWEST ALONG WHITEWATER CANYON, TO SEC. 36, T. 1 S., R. 2 E.	
Whitewater Creek, sec. 36, T. 1 S., R. 2 E., 475 feet southwest of junction with creek from the south, southwest side of Whitewater Canyon, 500 feet south of cluster of pine trees, in vertical face of granite ledge, 1.5 feet above ground; aluminum tablet stamped "3438 S B"-----	3, 438.608
DRY MORONGO, WEST TO CORNER OF TS. 1 AND 2 S., RS. 3 AND 4 E.	
Ts. 1 and 2 S., Rs. 3 and 4 E., common corner, which is also corner of the San Bernardino Forest Reserve and is marked "No. 99" in top of cement-filled iron post 4 inches square; aluminum tablet stamped "3075 S B"-----	3, 075.519
SEC. 14, T. 1 S., R. 4 E., NORTHWEST UP LITTLE MORONGO CANYON, TO T. 1 N., RANGE 4 E. (ABOUT SEC. 30, UNSURVEYED).	
Little Morongo, on south side of canyon, at second water camping place, in red granite ledge 10 feet above creek bed; aluminum tablet stamped "4831 S B"-----	4, 831.526
CALABASAS, DOWNEY, FERNANDO, GOLETA SPECIAL, HUENEME, PASADENA, REDONDO, SAN PEDRO, SANTA BARBARA SPECIAL, SANTA MONICA, SANTA PAULA, SANTA SUSANA, TUJUNGA, AND VENTURA 15' QUADRANGLES; CAMULOS, GUADALUPE, LOMPOC, MOUNT PINOS, PALMDALE, SANTA YNEZ, AND TEJON 30' QUADRANGLES.	

KERN, LOS ANGELES, SAN LUIS OBISPO, SANTA BARBARA, AND VENTURA COUNTIES.

The elevations in the following list are based upon the 1906 precise-level line of the United States Coast and Geodetic Survey from San Diego along the Atchison, Topeka and Santa Fe Railroad via San Bernardino to Barstow, and are derived by a readjustment of leveling mostly heretofore published in Bulletin No. 185 and in Appendix to the Nineteenth Annual Report. The elevations previously published were based upon double-rodged primary lines from Los Angeles to Pacoima, Santa Monica, San Bernardino, and San Pedro, based upon the United States Coast and Geodetic Survey gage record at San Pedro. The unadjusted values corrected to San Bernardino would now close 0.7 foot high at San Pedro and 0.2 foot low at Santa Monica, but an adjustment has been made arbitrarily adding 0.4

foot at San Pedro and 0.9 foot to the elevation (see Nineteenth Annual Report) at Santa Monica to equal the Coast and Geodetic Survey value there; also 0.5 foot has been added at Los Angeles and 0.7 foot at Pacoima. The elevations are further controlled by precise leveling of 1902 along the Southern Pacific Railway from Pacoima to Mohave, bearing additional rod correction found by rerunning a portion in 1906 near Mohave, and adjusted to the new accepted heights at these points.

The leveling was done as follows: By Mr. H. S. Crowe, levelman, on San Pedro, Redondo, Downey, Pasadena, and Tujunga quadrangles in 1897; on Fernando quadrangle in 1897-98; on Santa Monica quadrangle in 1897 and 1900; on Santa Susana quadrangle in 1898 and 1900; on Calabasas 15' and remainder of Camulos 30' quadrangles in 1900; on Hueneme and Santa Paula quadrangles in 1900 and 1901; on Ventura, Santa Barbara Special, and Mount Pinos quadrangles in 1901; on Palmdale quadrangle in 1900; on Tejon quadrangle in 1900 and 1901; and on Goleta Special, Santa Ynez, and Lompoc quadrangles in 1901-2. Additional work was done on Lompoc quadrangle in 1903-4 by Mr. S. N. Stoner, and in 1903 by Mr. C. L. Nelson. Work on Guadalupe quadrangle was done in 1903-4 by Mr. Stoner.

In the spring of 1907 a prism level yard rod line of levels was run by Mr. Charles H. Lee, for the Los Angeles aqueduct, under Mr. J. B. Lippincott, which agrees well between Pacoima, Saugus, and Mohave with the adjusted elevations of this list, but disagrees grossly with Crowe's levels of this list on Tejon quadrangle, increasing elevation at San Francisco Canyon 2 feet, lowering elevation at Fairmont 1.5 feet, and making various other corrections between these extremes, which show Crowe's lines to be somewhat unreliable; but no readjustment has been yet made of Crowe's lines on account of this information.

SAN PEDRO QUADRANGLE.

AT SAN PEDRO.

	Feet.
San Pedro, top of upper stone of foundation to brick building of	
Bank of San Pedro, U. S. C. & G. S. bench mark (of 1890) ^a -----	22.74

REDONDO QUADRANGLE.

SAN PEDRO, NORTH ALONG SOUTHERN PACIFIC RAILROAD, TO WILMINGTON (DOUBLE RODDED LINE).

Wilmington, 152 feet from northeast corner of railroad water tank	
and 153 feet from southwest corner of station; iron post	
stamped "7" -----	6.915

^a To U. S. C. & G. S. elevation 0.4 foot has been added.

DOWNEY QUADRANGLE.

WILMINGTON, NORTH ALONG SOUTHERN PACIFIC RAILROAD, TO CLEMENT JUNCTION, LOS ANGELES (DOUBLE-RODDED LINE).

	Feet.
Thenard Junction, about 100 feet west of station sign and 1 foot from telegraph pole; iron post stamped "33"-----	33. 007
Cerritos, corner of Dominquez and Railroad avenues, 1 foot from corner of fence of railroad right of way and 96 feet from southwest corner of railroad building; iron post stamped "32"-----	31. 903
Compton, 1 foot from fence in front of station, 88 feet from northeast corner of station building and 30 feet from north post of gate to R. Barker's residence, fronting station; iron post stamped "67"-----	67. 038
Florence, between station building and small outhouse, 39 feet from southwest corner of station building and 5 feet from large palm tree; iron post stamped "136"-----	136. 052

PASADENA QUADRANGLE.

CLEMENT JUNCTION, NORTH VIA LOS ANGELES, TO TROPICO (DOUBLE-RODDED LINE).

Los Angeles:

Clement Junction, at intersection of fence lines; iron post stamped "220"-----	220. 470
Arcade station, 3 inches north of center post of northwest tower of; copper plug set in asphaltum, stamped "256"-----	256. 179
Post-Office Building, in north stone buttress of main entrance to, on Main street, between Winston and Fifth streets; bronze tablet stamped "270"-----	270. 619
City Hall Building, on Broadway, about 3 feet above the northern steps to front entrance; bronze tablet stamped "286"-----	286. 633
County court-house, in granite buttress of, right hand of main steps to building, which is at southeast corner of Broadway and Temple street; bronze tablet stamped "338"-----	338. 523
Naud Junction, in concrete of floor of waiting room, alley at, 4 inches from side of baggage room and 8 inches from edge of concrete nearest railroad track; copper bolt stamped "282"-----	282. 733
Naud Junction, 0.5 mile east of, at Los Angeles River, southwest corner of railroad bridge, in concrete pier; copper bolt stamped "294"-----	294. 590
Junction warehouse, brick building, at Junction of San Fernando and Olympia streets, in front wall; bronze tablet stamped "306"-----	306. 403
Buena Vista street, bridge over Los Angeles River, 0.5 mile north of station, second bent from south end, 18 feet from California Southern and 12 feet from Southern Pacific railroad tracks, in northeast granite post; copper bolt stamped "314"-----	314. 546

LOS ANGELES, EAST ALONG SOUTHERN PACIFIC RAILROAD, TO BASSETT.

East Lake Inn, northeast corner of Eastlake avenue and Mission road, on south side of building and 1.2 feet from steps in concrete, at top of foundation; bronze tablet stamped "333"-----	333. 391
Aurant station, 0.75 mile west of, in top step of brick culvert on west side of railroad; copper bolt stamped "399"-----	399. 226
Shorb station, on south side of railroad yard, 99.5 feet southeast from corner of station and 55 feet west of signal tower building; iron post stamped "464"-----	464. 325

PRIMARY LEVELING.

71

	Feet.
Alhambra station, in the west corner of railroad park; iron post stamped "456"-----	456.547
San Gabriel, 85.6 feet from northeast corner of, and 94.9 feet from northwest corner of station building, 7.1 feet west from rain-gage post; iron post stamped "415"-----	415.993
Savannah, 1 foot from fence south of station and 75.9 feet from southeast corner of station; iron post stamped "300"-----	300.660
Savannah, in Western Union Telegraph pole, 73.3 feet north of station; bronze tablet stamped "292"-----	292.416

SANTA MONICA QUADRANGLE.

CLEMENT JUNCTION, LOS ANGELES, WEST ALONG SOUTHERN PACIFIC RAILROAD, TO SANTA MONICA (ADJUSTED DOUBLE-RODDED LINE).

University station, 1 foot west of telegraph pole and 65 feet south of southwest corner of station; iron post stamped "174"-----	174.851
Cienega siding, at northwest corner of fence for cattle corral and 50 feet west of center of track; iron post stamped "118"-----	118.934
Ivy station, in southwest corner of fence of cattle guard at road crossing, 150 feet northwest of station building; iron post stamped "103"-----	103.180
Palms, in front brick wall at northwest corner of warehouse, fifth course of bricks above water table and in center of second course of bricks from north end; bronze tablet stamped "126"-----	126.909
Home Junction, on east side of track near fence, 80 feet east from center of railroad building and 48 feet from center of track; iron post stamped "165"-----	165.323
Santa Monica, in brick wall of building used as bank on northeast corner of Oregon and Third streets; bronze tablet stamped "79"-----	79.400
Santa Monica, in concrete floor of railroad turntable foundation, 3.2 feet north of center of turntable, and 6 inches west of center of track at end of Long Wharf; copper bolt stamped "17"-----	17.510
Santa Monica, top surface of the railroad turntable at inner end of wharf (the turntable has a well-laid concrete foundation); U. S. C. & G. S. benchmark No. 1 (elevation by U. S. C. & G. S.)---	17.42

TROPICO, NORTHWEST ALONG SOUTHERN PACIFIC RAILROAD, TO PACOIMA (DOUBLE-RODDED LINE).

Tropico, 1.5 feet from northwest corner of fence around garden, 200 feet north of station building; iron post stamped "432"-----	432.289
Burbank, on west side of railroad track, 51 feet from center, 117 feet northwest from northwest corner of station; iron post stamped "563"-----	563.348
Dundee, near post-office building, 12.2 feet from northeast corner of building, 4.2 feet from eucalyptus tree, 600 feet west of railroad station; iron post stamped "760"-----	760.108

BURBANK, WEST ALONG CHATSWORTH PARK BRANCH RAILROAD, TO ENCINO.

MacNeil siding; top of rail-----	597.2
Garnsey siding; top of rail-----	663.6
Garnsey siding, 300 feet west of, 3.5 feet east of telegraph pole 479, 50 feet south of railroad track; iron post stamped "665 L. A."-----	665.635
Trestle 483 C, opposite, 50 feet south of center of track, 4 feet east of telegraph pole 484; iron post stamped "704 L. A."-----	704.933

FERNANDO QUADRANGLE.

PACOIMA, NORTHWEST ALONG SOUTHERN PACIFIC RAILROAD, TO FERNANDO; THENCE EAST UP TUJUNGA VALLEY INTO CANYON.

Feet.

Pacoima, at corner of fence, 165 feet northwest of northwest corner of brick station building; iron post stamped "1013" (beginning of precise line)-----	1, 013. 230
San Fernando, in southeast corner of brick wall of McClay & McClay Company's building on Johnson street; bronze tablet stamped "1066," recovered by precise levels-----	1, 066. 665
T. 2 N., R. 14 W., sec. 10, 0.3 mile west of road fork, 40 feet south from corner of old orchard, 4 feet north of crooked tree and 20 feet from center of wagon road; iron post stamped "1187"-----	1, 187. 837
T. 2 N., R. 13 W., sec. 6, 0.75 mile east of S. A. Johnson's house, 10 feet south of wagon road on township line; iron post stamped "1470"-----	1, 470. 898

SAUGUS, EAST ALONG SOUTHERN PACIFIC RAILROAD AND HIGHWAYS, TO RAVENNA (RECOVERED BY PRECISE LEVELING).

T. 4 N., R. 15 W., 4.6 feet from common corner secs. 13, 14, 23, and 24, road over tunnel, 15 feet from fence; iron post stamped "1565"-----	1, 564. 636
Lang's station, at north end of picket fence, 45 feet north of center of track, between hotel building and section house; iron post stamped "1690" (recovered by precise levels)-----	1, 689. 544
Steel bridge No. 11, on concrete bulkhead pier of, in Soledad Canyon, 11 miles south of Acton; copper bolt stamped "1822"-----	1, 821. 790
Steel bridge No. 5, on concrete pier bulkhead at northwest corner of; copper bolt stamped "1913"-----	1, 913. 053

SPUR NORTH UP AGUA DULCE CANYON.

T. 5 N., R. 14 W., sec. 34, 1.25 miles west of J. M. Talbot's house, 2 feet south of southeast corner of adobe house; iron post stamped "2258"-----	2, 257. 840
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SPUR NORTH UP MINT CANYON.

T. 4 N., R. 15 W., sec. 15, 2 miles north of railroad, in flat rock 12 by 12 by 8 inches on side of hill, about 30 feet north of spring; copper bolt stamped "1556"-----	1, 555. 511
T. 4 N., R. 15 W., sec. 2, northwest corner of W. H. Thomas's cabin, 4.75 miles from mouth of canyon; iron post stamped "1778"-----	1, 777. 721

TUJUNGA QUADRANGLE.

UP TUJUNGA CANYON, EAST ALONG ROAD, TO HOYT RANCH; THENCE NORTHEAST ALONG TRAIL UP CANYON AND OVER RIDGE, TO NORTH FORK TUJUNGA CREEK AT MOUTH OF MILL CREEK; THENCE NORTHEAST 2 MILES UP MILL CREEK, TO END OF WAGON ROAD.

Hoyt ranch, 0.7 mile northwest of, about 800 feet from creek crossing on brushy flat, 6.5 miles northeast of Montevista, in face of rock 14 by 5 by 3 feet, 2.7 feet above surface of ground; bronze tablet stamped "1888"-----	1, 888. 645
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	Feet.
Hoyt's ranch, 2.75 miles northeast of, in rock at foot of slope, pine tree growing in rock; copper bolt stamped "2115"-----	2, 115. 315
Bowlder 7 by 5 by 3 feet, on trail where it is in sight of Big Tujunga, about 1,500 feet up ridge; copper bolt stamped "2593"-----	2, 593. 905
Small summit, 1.1 miles on trail, in flat granite slab; copper bolt stamped "3526"-----	3, 526. 291
Summit of ridge, 50 feet east of, in granite bowlder 2 by 1 feet; copper bolt stamped "4398"-----	4, 398. 579
Junction of North Fork and Mill creeks, 0.5 mile northwest of, in granite bowlder 12 feet north of trail; copper bolt stamped "3935"-----	3, 935. 200
Junction of Mill Creek and North Fork of Big Tujunga, near trail from latter, in granite bowlder; copper bolt stamped "3056"-----	3, 056. 473
Mill Creek, 2 miles above mouth, 20 feet from north end of wagon road, in rock on south bank of Mill Creek at point where trail goes over ridge to Big Tujunga Creek; copper bolt stamped "3463"-----	3, 463. 749

MOUTH OF MILL CREEK SOUTHWEST TO MOUTH OF NORTH FORK OF TUJUNGA CREEK (SINGLE SPUR).

Vertical Falls, on North Fork, 35 feet in height, in ledge of rock on north side of creek, about 6 feet above water and 20 feet north of falls; bronze tablet stamped "2879"-----	2, 879. 72
Falls where North Fork empties into Big Tujunga Creek, 40 feet south of, in granite bowlder 6 by 5 by 4 feet on north side of North Fork where drift log is lodged; copper bolt stamped "2671"-----	2, 670. 977

END OF WAGON ROAD ON MILL CREEK, SOUTHEAST ACROSS RIDGE ALONG TRAIL, TO TUJUNGA CREEK; THENCE UP CREEK TRAIL, TO SOUTHEAST CORNER SEC. 5, T. 2 N., R. 11 W. (SINGLE SPUR).

Wickiup Canyon, 0.3 mile east of, on south side of Big Tujunga Creek, in bowlder 4 by 6 by 2 feet in bed of stream, 25 feet south of trail and 60 feet east of canyon, where trail goes down from ridge from Mill Creek, in oak stake driven in bank marked "B M." and near dead willow tree in stream; copper bolt stamped "3266"-----	3, 266. 066
Alder Creek, in bed of, at junction with Big Tujunga, in hole drilled in bowlder 8 by 8 by 12 feet; copper bolt stamped "3415"-----	3, 415. 462
T. 2 N., R. 11 W., sec. 5, near southeast corner of, 40 feet east of trail between Barley Flats and Mount Wilson, in face of granite ledge facing Tujunga River 60 feet east of pine tree 18 inches in diameter; bronze tablet stamped "4046"-----	4, 046. 138

UP MILL CREEK, NORTHEAST OVER DIVIDE AND NORTHWEST DOWN ALISO CANYON, TO ACTON.

Divide between Mill Creek and Aliso Canyon, 10 feet east of road; iron post stamped "5030"-----	5, 030. 964
Smith's stamp mill, 250 feet east of, in bowlder 6 by 6 by 4 feet at junction of roads going up Dump and Tie canyons; copper bolt stamped "4452"-----	4, 452. 098
Big Tujunga mines and Jones ranch, intersection of roads to, 6 miles east of Acton, 18 feet south of signboard; iron post stamped "3348"-----	3, 348. 151
Acton, 3 miles south of, 30 feet from northeast corner of stone house on big ridge; copper bolt stamped "3021"-----	3, 021. 701

	Feet.
Aliso Canyon, mouth of, 2 miles east of Acton, 1 foot west of sign-board; iron post stamped "2829"-----	2, 829. 711
Acton, in brick wall southeast corner of hotel; bronze tablet stamped "2700" (recovered by precise leveling)-----	2, 700. 771
ACTON, SOUTHEAST ALONG SOUTHERN PACIFIC RAILROAD TO RAVENNA (RECOVERED BY PRECISE LEVELING).	
Ravenna station, on east side of track, 58 feet east of door of office of station building and 3.5 feet from gum tree; iron post stamped "2468"-----	2, 468. 188
ALISO CANYON, NORTHEAST ALONG SOUTHERN PACIFIC RAILROAD, TO VINCENT (RECOVERED BY PRECISE LEVELING).	
Vincent, 500 feet north of station, in corner of jog in fence, and 500 feet west of center line of sec. 22, T. 5 N., R. 12 W.; iron post stamped "3219"-----	3, 219. 258
CALABASAS 15' (CAMULOS 30') QUADRANGLE.	
ENCINO, WEST ALONG CHATSWORTH PARK BRANCH RAILROAD, TO CANOGA; THENCE NORTH TO CHATSWORTH.	
Reseda, 2.7 miles west of, 40 feet west of center of county road, near first telegraph pole west of road crossing, 50 feet south of track; iron post stamped "773 L. A."-----	773. 859
NEAR CANOGA, SOUTHWEST ALONG ROAD, TO GRAPE ARBOR.	
Calabasas, 38 feet east of northeast corner of calaboose building, at southeast corner of picket fence around vineyard, 60 feet northwest of west end of bridge; iron post stamped "928 L. A."-----	928. 576
T. 1 N., R. 17 W., sec. 31, 4 feet north of southwest corner; iron post stamped "694 L. A."-----	694. 558
SANTA SUSANA 15' (CAMULOS 30') QUADRANGLE.	
FERNANDO, NORTH ALONG SOUTHERN PACIFIC RAILROAD, TO SAUGUS (RECOVERED BY PRECISE LEVELS).	
San Fernando tunnel, 0.25 mile south of south end of, at south end of white fence at end of yard at section house; iron post stamped "1417" (recovered by precise line)-----	1, 416. 373
San Fernando Pass, road over tunnel, 50 feet south of north end of cut east side of wall, 4 feet above floor of road; bronze tablet stamped "1799"-----	1, 799. 437
Newhall, between tree and telegraph pole, 27 feet south of station and 30 feet from center of track; iron post stamped "1273" (recovered by precise line)-----	1, 272. 195
Saugus, 18 inches from north corner of pump house, 18 feet from center of track and 33 feet from south corner of station building; iron post stamped "1171" (recovered by precise line)-----	1, 170. 641
FERNANDO, WEST ALONG WAGON ROAD, TO CHATSWORTH PARK.	
Chatsworth Park and Fernando, midway between, 5 feet south of fence corner, 37 feet south of center of road running east and west, and 45 feet east of road running north and south; iron post stamped "1031 L. A."-----	1, 031. 863

PRIMARY LEVELING.

75

Chatsworth Park, at corner of Simi road and Devonshire avenue, 1
foot north from southeast corner of Santa Susana schoolhouse, 11.5
inches below base of building; bronze tablet stamped "962 L. A."-- 963.154

Feet.

CHATSWORTH PARK, WEST ALONG ROAD OVER SANTA SUSANA PASS, TO SIMI.

Santa Susana Pass, at summit and 50 feet north of road, 33 feet
southwest of signpost, in large sandstone boulder 4.5 feet above
ground; bronze tablet stamped "1604 L. A."----- 1,604.321
Santa Susana, 30 feet southeast from southeast corner of bunk house,
165 feet southeast of section house, at corner of fence; iron post
stamped "961 L. A."----- 961.276

SAUGUS, WEST ALONG SOUTHERN PACIFIC RAILROAD, TO CAMULOS.

San Francisco ranch, 81 feet east from northeast corner of house of
superintendent, in northeast corner of yard, 2 feet from junction of
fence lines, 15 feet west of center of road; iron post stamped "1054
L. A."----- 1,053.601
Los Angeles and Ventura counties, 3.5 feet south of iron signpost of, 6
feet south of fence line, 50 feet north of center of track, 12 feet
south of county road; iron post stamped "858 L. A."----- 857.773

SAUGUS, NORTH ALONG ROAD, TO ST. FRANCIS RANCH.

T. 5 N., R. 16 W., sec. 34, south side of, in northwest corner of Edw.
D. Kichline's field, at foot of grade over mountain, 1 foot east of
corner of fence; iron post stamped "1235 L. A."----- 1,234.801

CAMULOS QUADRANGLE.

GRAPE ARBOR, WEST ALONG ROAD, TO RUSSELL VALLEY; THENCE NORTH TO SIMI.

Russell Valley, 2 miles east of, summit of pass between Vejer and
Newbury Park ranch, north side of road where ledge of sandstone
appears on surface, in center of most westerly slab of sandstone 10
by 4 by 1.5 feet; bronze tablet stamped "977 L. A."----- 977.431
Newbury Park ranch, in front of residence of W. H. Crowley, 30 feet
south of wagon road at west corner of fence; iron post stamped
"859 L. A."----- 859.749
Summit of pass from Crowley's to Simi, south side of road, in flat
sandstone; bronze tablet stamped "1289 L. A."----- 1,289.486
Simi, 1.3 miles southwest of, 18 feet east of marked corner of sec. 17,
T. 2 N., R. 18 W., 24 feet east of center of road at fence post; iron
post stamped "730 L. A."----- 730.453

SIMI, NORTHWEST ALONG ROAD VIA GRIMES CANYON, TO FILLMORE; THENCE EAST ALONG
SOUTHERN PACIFIC RAILROAD, TO CAMULOS.

Epworth, 39 feet east of center line of Buena Vista street, at corner
of Broadway, 87 feet southeast of southeast corner of fruit packing
house; iron post stamped "868 L. A."----- 868.898
Grimes ranch, sec. 7., T. 3 N., R. 19 W., 600 feet southwest of house,
100 feet east of corral, 30 feet east of small dry wash, 3 feet north
of gate post on wagon road; iron post stamped "642 L. A."----- 642.562

	Feet.
Fillmore, 125 feet southwest of southwest corner of station, 65 feet southeast of center of railroad and highway crossing, 1.5 feet north of fence corner; iron post stamped "460 L. A."-----	469.914
Buckhorn, 153 feet northeast of northeast corner of station, 50 feet north of track, 3 feet west of telegraph pole; iron post stamped "509 L. A."-----	508.493
Canulos, 200 feet south of southeast corner of station, 2.5 feet south of northwest corner of post-office; iron post stamped "732 L. A."--	731.437

FILLMORE, WEST ALONG SOUTHERN PACIFIC RAILROAD, TO SESPE.

Brownstone, in front of station; top of north rail-----	448.3
Sespe, 1,300 feet north of station, 50 feet south of main entrance to San Cayetano schoolhouse, 1 foot north of fence; iron post stamped "501 L. A."-----	502.382
Sespe, in front of station; top of north rail-----	456.0

RUSSEL RANCH, WEST AND NORTH IN CONEJO VALLEY VIA POTRERO, TO SOMIS; THENCE EAST TO SIMI.

Pass from Conejo to Potrero, 150 feet west of road, on slope of rock ledge in field; bronze tablet stamped "1315 L. A."-----	1,315.549
Guadalupe, El Conejo, and Calleguas grants, joint corner of, 10 feet north of road, in pile of rocks, at summit of ridge; iron post stamped "778 L. A."-----	778.704
Somis, 8 feet south of southeast corner of fence around public school, 15 feet west of public road; iron post stamped "288 L. A."-----	288.460
Moor Park, 20 feet southwest of southwest corner of station, 30 feet north of center of track; iron post stamped "511 L. A."-----	511.960

HUENEME QUADRANGLE.

SOMIS, SOUTHWEST ALONG SOUTHERN PACIFIC RAILROAD (SOMIS BRANCH), TO SUCROSA; THENCE WEST TO OXNARD; THENCE NORTH TO MONTALVO.

Springville, 1 mile south of, in T. 2 N., R. 21 W., 90 feet south of junction of Wood and Pleasant Valley roads, 1 foot east of east corner of schoolhouse; iron post stamped "53 L. A."-----	54.185
Oxnard, in front of station; top of south rail-----	50.0
Oxnard, 445 feet southwest of southwest corner of station, 1.3 feet west of west fence post; iron post stamped "48 L. A."-----	48.639
Montalvo, in front of station; top of north rail-----	95.9
Montalvo, 225 feet northwest of station, 35 feet east of road, 1 foot south of fence, 50 feet north of center of track; iron post stamped "93 L. A."-----	94.133

OXNARD, SOUTH ALONG WAGON ROAD, TO HUENEME; THENCE EAST AND NORTH TO SUCROSA SIDING.

Hueneme, at junction of Market and Main streets, west side of Bank of Hueneme, in eighth row of bricks above sidewalk and second horizontal row from sidewalk; bronze tablet stamped "8 L. A."--	8.494
Round Mountain, at north foot of, junction of road, 250 feet east of water trough on Conejo road, 2.5 feet west of signboard marked "Hueneme 8.75 m., Conejo county line 14.5 m., Montalvo 13 m., Saticoy 12.5 m."; iron post stamped "30 L. A."-----	30.338

PRIMARY LEVELING.

77

SANTA PAULA QUADRANGLE.

SESPE, SOUTHWEST ALONG SOUTHERN PACIFIC RAILROAD (SANTA BARBARA BRANCH), TO MONTALVO.

	Feet.
Santa Paula, 100 feet south of south side of station, at southwest corner of Ojai and Santa Barbara streets; iron post stamped "288 L. A."-----	288.363
Santa Paula, in front of station; top of rail-----	290.8
Saticoy, 80 feet south of center of station, at northeast corner of park on railroad reservation; iron post stamped "140 L. A."-----	149.302
Saticoy, in front of station; top of north rail-----	149.2

SATICOY, NORTHWEST 3 MILES ALONG WAGON ROAD, TO HARMAN BARRANCA.

Harman Barranca, on west side of northeast fork of, at north end of cultivated field on east slope of hill; iron post stamped "620 L. A."-----	629.572
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SATICOY, EAST ALONG WAGON ROAD, TO SOMIS.

Saticoy, 3.1 miles south of, at southwest corner of Santa Clara and Del Norte avenues, 60 feet west of signpost, in corner stake of ranch; 8-penny wire nail-----	114.54
Saticoy, 6.2 miles east of, at Center schoolhouse, in northwest corner of yard; iron post stamped "313 L. A."-----	313.567

SANTA PAULA, NORTH ALONG WAGON ROAD, TO SULPHUR MOUNTAIN SPRINGS; THENCE WEST TO NORDHOFF.

Sulphur Mountain Springs, 6 feet east of gate to, 50 feet north of cottage, 1 foot south of wire fence on north side of road; iron post stamped "1005 L. A."-----	1,005.610
Thatcher's school, 600 feet west of, 40 feet north of township corner, at southwest corner of sec. 34, T. 5 N., R. 22 W., south side of road, 6 feet east of telephone pole; iron post stamped "1323 L. A." (elevation by spur 2 miles north of main road)-----	1,323.516
Nordhoff, 5 feet north of southwest corner stake of schoolhouse lot, 35 feet north on center of road; iron post stamped "743 L. A."-----	743.389
Nordhoff, in front of station; top of rail-----	730.1

VENTURA QUADRANGLE.

MONTALVO, NORTHWEST ALONG SOUTHERN PACIFIC RAILROAD, TO CARPINTERIA.

Ventura, in front of station; top of north rail-----	48.0
Ventura, on east side of main entrance to county court-house, 2.4 feet west of northeast corner of tower, 1.4 feet above sidewalk; bronze tablet stamped "13 L. A."-----	14.095
Sea Cliff, in front of station; top of north rail-----	14.7
Punta Gorda, in front of station; top of rail-----	16.5
Punta Gorda schoolhouse, 600 feet east of, 100 feet west of milepost 514, in north corner of fence at road crossing, 25 feet east of road; iron post stamped "21 L. A."-----	22.020

VENTURA, NORTH ALONG SOUTHERN PACIFIC RAILROAD, TO NORDHOFF.

Lacrosse siding, at south end of, center of track-----	302.6
Lacrosse road crossing, 50 feet west of, opposite signpost marked "Matilija 8.75 m., Nordhoff 6.5 m., Santa Anna schoolhouse 3.5 m., Ventura 7.5 m."; iron post stamped "314 L. A."-----	314.786

	Feet.
Oakview spur, at switch stand; base of rail.....	481. 2
Mirror Lake, south end of, 45 feet northwest of road crossing, 3 feet south of signpost marked "Matilija 5.75 m., Nordhoff 4.25 m., Ventura 10.5 m."; iron post stamped "626 L. A.".....	626. 812
Mirror Lake; surface of water.....	611. 4
Long Valley spur, opposite waiting room; center of track.....	632. 9
Matilija spur, in front of waiting room; center of track.....	757. 5

NORDHOFF, NORTHWEST ALONG WAGON ROAD, TO MATILIJA.

Matilija, 100 feet west of post-office, at east end of corral, opposite feed barn, in large rock in fence; bronze tablet stamped "955 L. A."	955. 843
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CASITAS SWITCH, WEST ALONG WAGON ROAD, TO CARPINTERIA.

Casitas Pass, summit of, 15 feet north of center of road, near center line of sec. 34, T. 4 N., R. 24 W.; iron post stamped "1155 L. A." ..	1, 155. 317
Shepards, 0.2 mile south of, on sec. 25, T. 4 N., R. 25 W., 2 feet north of signpost marked "County line—Ventura 18 m., Santa Barbara 17 m.," near junction of road, on northwest bank of Rincon Creek; iron post stamped "213 L.A."	213. 661

PALMDALE QUADRANGLE.

MANZANA, EAST ALONG ROAD, TO FAIRMONT; THENCE SOUTH TO ELIZABETH LAKE; THENCE SOUTHEAST TO HAROLD (ALPINE).

Fairmont, 300 feet southeast of southeast corner of public school-house, at southeast corner of fence; iron post stamped "2786 L. A." ..	2, 785. 588
W. A. Spencer's house, 75 feet southeast from corner of, 1 foot south of fence corner; iron post stamped "2803 L. A."	2, 802. 809
Pedro Andrada's house, 60 feet north of, 2 feet northeast of sign-board at corner of road where it forks east and south; iron post stamped "3403 L. A."	3, 402. 719
Hill, on slope of, 25 feet south of road; iron post stamped "3177 L. A." ..	3, 176. 513
J. G. Ritter's house, 0.5 mile north of, 450 feet north of gate, 12 feet north of road at summit of ridge at head of valley; iron post stamped "3048 L. A."	3, 047. 223
Signpost marked "Alpine, 5 miles," 15 feet west of, 100 feet east of road up canyon, 200 feet south of road to Palmdale; iron post stamped "2831 L.A."	2, 830. 299
Una Lake, sec. 3, lot 8, T. 5 N., R. 12 W., 1.5 feet southeast of southeast corner of bunk house of South Antelope Valley Irrigation Company; iron post stamped "2820 L. A."	2, 819. 772
Harold siding (formerly Alpine), 1.5 feet west of northwest corner of fence around railroad section house, 9 feet east of center of track; iron post stamped "2826 L. A."	2, 826. 028

UNA LAKE, SOUTHEAST, TO LITTLE ROCK.

East Palmdale, 0.25 mile south of, in corner of fence, 40 feet north of center of road to Little Rock from East Palmdale, in sec. 6, T. 6 N., R. 11 W., 450 feet northwest of section corner; iron post stamped "2682"	2,681. 639
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PRIMARY LEVELING.

79

Feet.

Little Rock, inside of fence at Chaplin ranch, 54 feet east from post-office building and 25 feet east of quarter corner on west side of sec. 13, T. 5 N., R. 11 W.; iron post stamped "2910"----- 2,910.249

ELIZABETH LAKE, SOUTHWEST, TO ST. FRANCIS RANCH.

P. Andrade's house, 60 feet north of, 2 feet northeast of signboard at forks of road; iron post stamped "3403 L. A."----- 3,402.558
 Juan de Cellis's house, 1 mile south of, at turn of road on top of first hill south of bridge; iron post stamped "2604 L. A."----- 2,603.774
 Canyon, at turn of road in, 15 feet below small ditch where it turns around point of hill; iron post stamped "1913 L. A."----- 1,912.124

TEJON QUADRANGLE.

AT SEC. 11, T. 5 N., R. 16 W.

T. 5 N., R. 16 W., sec. 11, 1 mile south of St. Francis ranch, 40 feet west of road, on small flat, 5 feet east of cottonwood tree; iron post stamped "1600 L. A."----- 1,598.988

CASTAC, NORTHWEST ALONG WAGON ROAD AND TRAIL VIA CASTAC, PIRU, AND GRAPE-VINE CREEKS TO ROSE STATION.

Carmichael's ranch, 1.5 feet west of northwest corner of fence, on north side of lane; iron post stamped "1172 L. A."----- 1,171.538
 Victor Cordova's residence, west side of, at west corner of fence around garden, 500 feet north of wagon road, on mesa above creek; iron post stamped "1457 L. A."----- 1,456.750
 House of Frank S. Randolph, 0.3 mile from, 12 feet east of trail to Oak Flats, at summit of ridge from Castac Creek; iron post stamped "2807 L. A."----- 2,806.940
 Spring Creek, 1,500 feet north of where it empties into Piru Creek, 45 feet north of trail where it turns north up Piru Canyon, on flat side of rock 6 by 2 by 4 feet; bronze tablet stamped "2060 L. A."-- 2,059.276
 Bainbridge's house, 250 feet northeast of, sec. 34, T. 7 N., R. 18 W., at north corner of fence around hog corral, at south end of and 30 feet east of center of wagon road to house; iron post stamped "2307 L. A."----- 2,306.266
 Alamo ranch, in jog of fence around house of M. C. Bailey; iron post stamped "2796 L. A."----- 2,795.270
 German ranch, Charles Schliesmayer's ranch, 1.5 feet west of corner, at intersection of fence lines, 45 feet south of road; iron post stamped "3463 L. A."----- 3,462.718
 Tejon Pass, at summit, 6 feet south of brush fence and 40 feet north of wagon road; iron post stamped "4230 L. A."----- 4,229.933
 Los Angeles and Kern counties; 6 penny wire nail in notch on post marking line----- 3,750.18
 Los Angeles and Kern counties, 2.5 feet north of line post; iron post stamped "3744 L. A."----- 3,744.104
 Fort Tejon, in front of gatepost at entrance to residence of superintendent of Castac ranch, 45 feet west of wagon road; iron post stamped "3174 L. A."----- 3,173.480
 Rose station, 0.5 mile south of top of grade from, 20 feet east of road at top of hill where road runs across low place to the south; iron post stamped "2132 L. A."----- 2,131.523

T. 10 N., R. 19 W., near northwest corner sec. 4, 12 feet south of gate across road, 10 feet east of center of road, 2 feet south of post 6 by 8 inches; iron post stamped "1085 L. A."----- Feet.
1, 084. 684

LUBEC, WEST TO SOLDIERS' HOME CAMP.

Soldiers' Home Camp, opposite deserted ranch house, 4 feet west of fence line, 6 feet south of wagon road; iron post stamped "4471 " 4, 471. 721

GERMAN, EAST ALONG ROAD, VIA QUAIL AND NEENACH, TO MANZANA.

McKenzie's house, 160 feet northeast of northeast corner of, at north-east corner of intersection of fences, 50 feet south of road; iron post stamped "3393 L. A."----- 3, 392. 690
La Liebre ranch, at corner of fence where road turns to east, 0.5 mile west of brick house on county road; iron post stamped "3061 L. A." ----- 3, 090. 936
Henry Hatch's ranch (Vala Vista), at residence, 2 feet east of gate, in front of picket fence; iron post stamped "3039 L. A."----- 3, 039. 018
Manzana, opposite driveway from main road to post-office and store of A. E. Silvey, on east side of road, 1 foot south of fence post; iron post stamped "2870 L. A."----- 2, 869. 559

MOUNT PINOS QUADRANGLE.

MATILILJA, NORTH ALONG TRAIL, TO OZENA.

Matililja Creek, north side of, 50 feet east of junction with Upper North Fork, west side of trail, at mouth of canyon, on sandstone boulder, 3.5 by 2.5 feet; bronze tablet stamped "1589 L. A."----- 1, 590. 139
Ortega Hill, at summit; on ridge between North Fork of Matililja River and Sespe River, on rock boulder 2.5 feet by 3 feet; bronze tablet stamped "4970 L. A."----- 4, 971. 315
Sespe River, 450 feet east of small cabin, mouth of canyon, 25 feet east of where trail leaves to go over Pine Mountain, in ledge of sandstone; bronze tablet stamped "4144 L. A."----- 4, 145. 021
Pine Mountain, 3 miles south of Ozena; at summit of ridge, 6 feet east of trail, in block of hard rock 18 by 24 inches; bronze tablet stamped "5314 L. A."----- 5, 314. 963
Ozena, 10 feet southwest of southwest corner of post-office, 10 feet north of wagon road; iron post stamped "3576 L. A."----- 3, 576. 691

OZENA, NORTHEAST ALONG WAGON ROAD, TO SOLDIERS' HOME CAMP NEAR LUBEC.

Ozena, 6 miles east of, at junction of canyons, 20 feet east of road where road to Lockwood Valley turns north, north end of grade; iron post stamped "4017 L. A."----- 4, 017. 421
Cuyama and Lockwood valleys, summit of ridge divide between, 8 feet north of wagon road; iron post stamped "5516 L. A."----- 5, 516. 643
Griffin, 1,200 feet northwest of residence of S. Snedden, 2 feet south of corner of fence at intersection, at turn of road; iron post stamped "4871 L. A."----- 4, 871. 830
Griffin and Cuddy's ranches, summit of divide between, 25 feet east of road; iron post stamped "5556 L. A."----- 5, 556. 014

PRIMARY LEVELING.

81

OZENA NORTHWEST ALONG WAGON ROAD TO SEC. 19, T. 9 N., R. 24 W.

	Feet.
T. 8 N., R. 24 W., sec. 8, south side of, 1.2 feet north of county-line post marked "C. L. 25" on north side, "V" on east side, and "S. B." on south side, 60 feet south of road; iron post stamped "3100 L. A."-----	3, 101. 168
T. 9 N., R. 24 W., sec. 19, 600 feet south of, George Root's adobe house, north edge of road, in corner of fence at junction; iron post stamped "2749 L. A."-----	2, 750. 005

SANTA BARBARA SPECIAL QUADRANGLE.

CARPINTERIA, WEST ALONG SOUTHERN PACIFIC RAILROAD, TO SANTA BARBARA.

Carpinteria, 30 feet east of southeast corner of station, 35 feet north of main track, 2 feet east of telegraph pole; iron post stamped "11 L. A."-----	11. 710
Serena, at switch stand; top of rail-----	28. 3
Ortega siding, in front of signboard; top of south rail-----	73. 8
Summerland, 30 feet east of east end of station, 1 foot east of telegraph pole, 60 feet north of center of track; iron post stamped "52 L. A."-----	52. 789
Summerland, in front of station; top of rail-----	52. 8
Miramar; top of rail-----	23. 6
Santa Barbara, on block 192, at west corner of City Hall; iron post stamped "37 L. A."-----	38. 011
Santa Barbara, Victoria street, in front of station; top of north rail-----	66. 7
Santa Barbara, 1.3 miles northwest of Victoria street station, in corner of fence at private road crossing, 300 feet east of east end of through cut, 40 feet north of track, 30 feet east of lone cottonwood tree; iron post stamped "128 L. A."-----	120. 237

GOLETA SPECIAL QUADRANGLE.

SANTA BARBARA, WEST ALONG SOUTHERN PACIFIC RAILROAD, TO CAPITAN.

Irma siding, opposite signboard; top of rail-----	158. 4
Goleta, 70 feet east of windmill frame, 120 feet south of center of track, 2 feet east of corner of fence, east side of road; iron post stamped "43 L. A."-----	43. 530
Elwood, in front of station; top of north rail-----	85. 6
Elwood, 1.7 miles west of, 600 feet east of milepost 358, at road crossing, 20 feet north of track, near fence; iron post stamped "57 L. A."-----	58. 212
Naples, in front of station; top of north rail-----	96. 2

SANTA BARBARA, WEST ALONG ROAD, TO NEAR GOLETA; THENCE NORTH OVER SAN MARCOS PASS, TO COLD SPRING CANYON.

Mrs. D. Pico Ruis's house, 45 feet north of northeast corner, 100 feet southwest of road to Laurel Springs, 2 feet south of sandstone boulder 7 by 6 by 6 feet; iron post stamped "1526 L. A."-----	1, 527. 336
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GOLETA SPECIAL (SANTA YNEZ 30') QUADRANGLE.

AT COLD SPRING CANYON.

	Feet.
Cold Springs Hotel, south side of driveway to, on first terrace on west side of main road; iron post stamped "1630 L. A."-----	1, 631.431

SANTA YNEZ 30' QUADRANGLE.

COLD SPRING CANYON, NORTHWEST, TO NEAR SANTA YNEZ.

San Marcos ranch, 100 feet south of old abode ruin, 30 feet west of road, 20 feet east of gate, in corner of fence; iron post stamped "842 L. A."-----	842.818
San Marcos ranch, 5.8 miles northwest of, 5 feet north of road, at down-grade turn to cross canyon; iron post stamped "696 L. A."---	696.911

SAN RAFAEL, NORTHEAST ALONG TRAIL, TO WASIOJA SCHOOL.

San Rafael Mountain; summit of trail-----	4, 374
Davy Brown's cabin, 80 feet southwest of southwest corner of, 100 feet south of creek crossing, 30 feet west of northwest corner of trail, at northwest corner of fence, in slab of sandstone 2 by 2 feet; bronze tablet stamped "2038 L. A."-----	2, 038.767
Manzana schoolhouse, 4.8 miles southeast of, on top of ridge, about 7 feet south of trail, where creek makes big bend to north, in slab of sandstone; bronze tablet stamped "1511 L. A."-----	1, 512.300
Manzana schoolhouse, east of, at foot of slope, 60 feet west of road, 600 feet south of mouth of Manzana Creek, in sandstone boulder, 6 by 5 by 3 feet; bronze tablet stamped "1163 L. A."-----	1, 164.013
Williams Canyon, mouth of, on west bank, 750 feet north of adobe house, 30 feet south of road, in block of sandstone 18 by 30 inches; bronze tablet stamped "1489 L. A."-----	1, 490.344
Williams Canyon, 5.1 miles northwest of mouth of, on north edge of trail, at mouth of small ravine, on top of cement gravel boulder 8 by 5 inches by 4 feet; bronze tablet stamped "3009 L. A."-----	3, 009.980

SEC. 19, T. 9 N., R. 24 W., NORTHWEST ALONG CUYAMA RIVER ROAD AND OVER RIDGE, TO WASIOJA.

T. 10 N., R. 25 W., sec. 33, intersection of east and west and north and south fence lines, 150 feet south of road; iron post stamped "2404 L. A."-----	2, 405.320
Cuyama ranch, at turn of road to house, 300 feet southwest of southwest corner of adobe house, 100 feet east of southwest corner of cattle corral, in southwest corner of fence; iron post stamped "2180 L. A."-----	2, 180.912
Agua Caliente ranch, 2.2 miles west of east boundary of, 30 feet north of road, on flat on Agua Caliente ranch; iron post stamped "1935 L. A."-----	1, 935.792
Green Canyon, mouth of, foot of slope, 15 feet east of road at turn up canyon where road leaves Cuyama River and goes over mesa to Wasioja; iron post stamped "1784 L. A."-----	1, 784.899
Wasioja schoolhouse (3 miles east of Wasioja), 1.5 feet west of northeast corner of building; iron post stamped "2352 L. A."-----	2, 352.663
Wasioja, 1 foot north of northwest corner of residence of J. B. Malory, in sec. 7, T. 10 N., R. 28 W.; iron post stamped "2303 L. A."--	2, 393.950

PRIMARY LEVELING.

83

LOMPOC 30' QUADRANGLE.

CAPITAN, WEST ALONG SOUTHERN PACIFIC RAILROAD, TO GAVIOTA.

	Feet.
Capitan, 1.8 miles east of, 1 foot west of milepost 352, 25 feet north of track; iron post stamped "109 L. A."-----	109. 720
Capitan siding, in front of signboard; top of north rail-----	75. 3
Morella siding; top of north rail-----	47. 1
Tajiquas siding, 135 feet east of northeast corner of fence around railroad section house lot, 200 feet north of center of track, 50 feet south of road, 30 feet west of gate in fence; iron post stamped "59 L. A."-----	59. 813
Gaviota, in front of telegraph office; top of south rail-----	94. 9
Gaviota, 125 feet south of southwest corner of station, 80 feet south of center of track, against fence on edge of bluff above beach; iron post stamped "94 L. A."-----	93. 869

GAVIOTA, WEST ALONG SOUTHERN PACIFIC RAILROAD, TO JALAMA.

Santa Anita switch, at road crossing; center of track-----	64. 2
Santa Anita switch, 1 mlie west of, 355 feet east of signpost, 185 feet west of milepost 334, 20 feet south of track; iron post stamped "48 L. A."-----	48. 281
Gata switch, at road crossing; top of rail-----	51. 9
Concepcion, 200 feet northwest of station, 6 feet east of northeast support of water tank; iron post stamped "112 L. A."-----	112. 427
Concepcion, in front of station; center of track-----	111. 4

GAVIOTA, NORTH ALONG WAGON ROAD, TO LOS OLIVOS.

Las Cruces, 1 foot south of northeast corner of fence around public school; iron post stamped "339 L. A."-----	339. 043
Nojoqui Pass, summit of, 25 feet south of road, on bench; iron post stamped "879 L. A."-----	879. 296
Old Santa Ynez mission, 35 feet northeast of gate at entrance to grounds, south edge of road, at corner of fence; iron post stamped "495 L. A."-----	495. 415

LOS OLIVOS, NORTHWEST ALONG PACIFIC COAST RAILWAY, TO SANTA MARIA; THENCE NORTH-EAST, ALONG HIGHWAY, TO SUEY RANCH.

Los Olivos, 1 foot north of south corner of public school building, 1 foot west of brick foundation; iron post stamped "836 L. A."-----	836. 150
Zaca, in front of station; base of west rail-----	774. 7
Calkin siding, west end of, 1 foot south of fence, 60 feet northeast of road crossing; iron post stamped "939 L. A."-----	939. 141
Wigmore siding, in front of signboard; base of south rail-----	751. 3
Los Alamos, road crossing at station; top of rail-----	569.
Los Alamos public school, in northwest corner of lot, 1 foot east of junction of fence lines; iron post stamped "569 L. A."-----	569. 324
Los Alamos, 4 miles west of, at point of curve near telegraph pole, 31 feet south of track; iron post stamped "425 L. A."-----	425. 279
Harris, in front of station; top of east rail-----	308. 3
Harris, 1.5 miles north of, top of bank, through cut, 30 feet east of track, 1 foot west of fence, between two crossings of creek; iron post stamped "378 L. A."-----	378. 370
Blake, in front of station; top of rail-----	400. 7
Divide, in front of station; top of rail-----	509. 2

	Feet.
Graciosa schoolhouse, 15 feet south of northeast corner of fence around, 150 feet west of road crossing at track; iron post stamped "314 L. A."-----	314. 411
Lake View, in front of station; top of east rail-----	253. 8
Santa Maria, in front of station; top of east rail-----	203. 4
Santa Maria, 140 feet east of east side of Pacific Coast Railway Company's station, 2 feet north of corner post of fence at northeast corner of Chapel street and Railroad reservation; iron post stamped "204 L. A."-----	204. 496
Suey ranch house, at entrance to grounds, 8 feet east of gatepost at junction of fence lines, 20 feet west of center of road; iron post stamped "377 L. A."-----	377. 067
SANTA YNEZ MISSION, EAST VIA SANTA YNEZ, TO FERRY; THENCE NORTH, VIA SANTA AGUEDA CREEK, TO SAN RAFAEL MOUNTAIN.	
Santa Ynez, at ferry crossing, 30 feet west of road, 15 feet south of tree to which cable is fastened, on flat; iron post stamped "522 L. A."-----	523. 646
Santa Agueda (St. Agnes) Creek, 5 miles north of junction with Santa Ynez River, line between Donovan ranch and College pasture, 20 feet west of gate in fence, 85 feet west of creek; iron post stamped "807 L. A."-----	809. 016
Los Olivos, 7.5 miles northeast of, 2.7 miles west of Birabent's house, at junction of small canyon below grade that turns north; iron post stamped "1501 L. A."-----	1, 502. 976
Birabent's house, 1.7 miles east of, 30 feet south of wagon road, on ridge near summit; iron post stamped "2982 L. A."-----	2, 984. 066
LOS ALAMOS, SOUTHWEST ALONG COUNTY ROAD VIA SANTA RITA (STEWART), TO LOMPOC; THENCE SOUTHEAST TO LAS CRUCES.	
Los Alamos, 6.3 miles southwest of, on saddle between two ridges, on west side of road, 25 feet south of gate in fence; iron post stamped "1476 L. A."-----	1, 476. 629
Stewart (Santa Rita), 0.8 mile west of, in southwest corner of field, on north side of road, at corner of lane to barnyard of D. Streeter; iron post stamped "415 L. A."-----	415. 297
Purissima Mission Building, 0.3 mile south of ruins of, at southwest corner of road where it turns south, opposite county tank and water trough; iron post stamped "112 L. A."-----	112. 210
Lompoc, at station of Southern Pacific Railroad, in front of telegraph office; top of south rail-----	94. 9
Lompoc, at southwest corner of Railroad avenue and Eighth street, in northeast corner of fence around public schoolhouse lot, 36 feet south of main track; iron post stamped "93 L. A."-----	93. 588
Lompoc, 4.6 miles southeast of, south side of gate, on east side of main road, in east corner of fence at intersection of fences; iron post stamped "238 L. A."-----	237. 971
San Julian ranch, 0.9 mile west of house, in corner of fence, 30 feet south of gate; iron post stamped "603 L. A."-----	603. 065
Las Cruces, 4.1 miles northwest of, 30 feet north of road, 40 feet south of telephone pole, 2.5 feet south of white stake No. 24, in mound of rocks; iron post stamped "927 L. A."-----	926. 752

SANTA YNEZ MISSION, WEST ALONG ROAD TO STEWART.

	Feet.
Santa Rita (Stewart), 4.3 miles southeast of, road at culvert, 6 feet west of road, at summit; iron post stamped "552 L. A."-----	552.022

SANTA MARIA, SOUTHEAST VIA GAREY AND CAT CANYON, TO LOS ALAMOS.

Santa Maria, 5.8 miles southeast of, 75 feet south of small frame house on land owned by Mr. Blockman, 50 feet south of poplar tree 18 inches in diameter, 15 feet southwest of right turn in road, 2 feet southwest of fence corner; iron post stamped "322 L. A."----	321.920
Garey, 60 feet north and 10 feet east of schoolhouse, 6 feet southwest of northeast corner of fence around schoolhouse; iron post stamped "376 L. A."-----	376.063
Garey, 4.8 miles southeast of, 70 feet northeast of Hopedale schoolhouse, 150 feet south of road, 20 feet west of fence; iron post stamped "596 L. A."-----	596.067
Garey, 8 miles southeast of, 12 feet southeast of road at summit; iron post stamped "1252 L. A."-----	1,252.001

GUADALUPE QUADRANGLE.

SANTA MARIA, WEST ALONG COUNTY ROAD, TO GUADALUPE.

Bennett schoolhouse, in southeast corner of school yard, 8 feet from corner of fence; iron post stamped "144 L. A."-----	144.197
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GUADALUPE, SOUTH ALONG SOUTHERN PACIFIC RAILROAD, TO JALAMA.

Guadalupe, 0.25 mile south of station, 100 feet north of point where switch leaves for sugar factory, 30 feet west of switch target at south end of Guadalupe yards, 50 feet north of county road, at south end of fence; iron post stamped "84 L. A."-----	84.063
Waldorf, 3 feet north of signpost; iron post stamped "201 L. A."---	201.668
Casmalia, 100 feet south of, south side of track, 30 feet west of wagon road; iron post stamped "291 L. A."-----	291.092
Narlon sign post, 3 feet north of, east side of track; iron post stamped "129 L. A."-----	129.200
Lompoc Landing, 60 feet west of crossing signpost, at road crossing, in corner of fence; iron post stamped "158 L. A."-----	158.026
Surf, 300 feet north of station, north side of wagon road, near southwest point of Y, 6 feet northeast of crossing signpost; iron post stamped "36 L. A."-----	35.600
Surf, in front of station; center of track-----	46.0
Weser, opposite signpost; center of track-----	133.1
Honda, signpost; center of track-----	108.6
Honda, 900 feet south of signpost, 300 feet north of south end of switch, 3 feet southwest of railroad crossing signpost; iron post stamped "110 L. A."-----	110.738
Arguello, at signpost; top of rail-----	173.7
Arguello, 30 feet east of east end of switch, 30 feet north of track, opposite white post; iron post stamped "161 L. A."-----	160.789
Sudden, west end of gate leading into station, 250 feet west of telegraph office; iron post stamped "85 L. A."-----	84.588

	Feet.
Jalama Creek, 50 feet north of north end of bridge over, 30 feet west of track, opposite large red water tank; iron post stamped "96 L. A."-----	95.748
Jalama, switch signpost; center of track-----	102.4

NARLON, EAST ALONG ROAD, TO HARRIS.

Narlon, 5 miles southeast of, south of San Antonio Creek, at foot of Barker's grade on Lompoc road, at southeast corner of wire fence, in boulder 24 by 36 by 36 inches above ground; aluminum tablet stamped "95 L. A."-----	95.462
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SURF, EAST ALONG SOUTHERN PACIFIC RAILROAD (LOMPOC BRANCH), TO LOMPOC.

Baroda, 3.5 miles southeast of, 30 feet west of county windmill No. 11, southwest corner of railroad crossing inclosure; iron post stamped "31 L. A."-----	30.080
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BALLARAT, FURNACE CREEK, AND PILOT PEAK, 1° QUADRANGLES (WHICH INCLUDE VARIOUS 30' QUADRANGLES NOT MENTIONED); BARSTOW 30' QUADRANGLE, AND RANDSBURG 15' QUADRANGLE.

INTO, KERN, AND SAN BERNARDINO COUNTIES.

The elevations in the following list are based upon the precise line Mohave, Cal., to Lida, Nev., of the United States Geological Survey and upon an elevation at Barstow determined by the United States Coast and Geodetic Survey in 1906 by precise leveling from San Diego.

The leveling was done mostly by Mr. L. F. Biggs, levelman, in 1907. Part of the work on Randsburg quadrangle was done in 1900 under Mr. L. C. Fletcher, topographer, by Mr. C. C. Ward, levelman, republished from Bulletin No. 185 corrected, and additional work on Pilot Peak 1° quadrangle and part of the work on Ballarat 1° quadrangle was done in 1905 by Messrs. Biggs and Ress Philips, and in 1906 by Mr. Philips. The 1906 and 1907 lines were run single with prism level and yard rods.

The bench marks are stamped serially or with figures of elevation, or both, and with datum letters. Those stamped "J" on Randsburg quadrangle are stamped with figures of elevation about 7 feet too great, and those of 1905-6, having been stamped prior to office reduction, are stamped about 1 to 4 feet too low.

BARSTOW 30' QUADRANGLE.

BARSTOW, NORTH 6 MILES ALONG ROAD TOWARD BALLARAT.

	Feet.
Barstow, 215 meters west of Atchison, Topeka and Santa Fe station, in fence corner of land of Charles O'Donnell; top of stone post (U. S. Coast and Geodetic Survey B. M. H. 1906)-----	2,101.707

	Feet.
Barstow, 2.6 miles north of, 20 feet west of road; iron post stamped "B 2386 1906"-----	2, 386. 487
Barstow, 6 miles north of, at Forks of roads; iron post stamped "B 2695 1906"-----	2, 691. 094

PILOT PEAK 1° QUADRANGLE.

POINT 6 MILES NORTH OF BARSTOW, TO BALLARAT.

Barstow, 9 miles north of, 10 feet north of 18-inch Yucca; iron post stamped "B 2892 1906"-----	2, 892. 427
Barstow, 12.5 miles north of, summit 30 feet west of road; iron post stamped "B 3960 1907"-----	3,960. 261
Barstow, 15 miles north of, 20 feet east of road; iron post stamped "B 3679 1907"-----	3, 679. 390
Barstow, 18.2 miles north of, 20 feet east of road; iron post stamped "B 3306 1907"-----	3, 306. 461
Barstow, 21.3 miles north of, 20 feet east of road; iron post stamped "B 3221 1907"-----	3, 220. 762
Barstow, 24.8 miles north of, 20 feet east of road, 200 feet south of dry lake; iron post stamped "B 3006 1907"-----	3, 005. 657
Copper City, 7.3 miles south of, 20 feet east of road; iron post stamped "B 3035 1907"-----	3, 035. 070
Copper City, 3.5 miles south of, 20 feet east of road; iron post stamped "B 3291 1907"-----	3, 291. 006
Copper City House, 100 feet east of, iron post stamped "B 4001 1907"-----	4, 000. 932
Copper City, 3.2 miles north of, on summit 15 feet west of road; iron post stamped "4402 B 1907"-----	4, 402. 326
Granite Wells, junction of roads, large bowlder; aluminum tablet stamped "B 3936 1907"-----	3, 939. 564
Granite Wells, 2.7 miles north of, 40 feet east of road, sandstone ledge; aluminum tablet stamped "B 3404 1907"-----	3, 403. 590
Granite Wells, 6 miles north of, 40 feet east of road, bowlder; aluminum tablet stamped "B 2719 1907"-----	2, 718. 586
Granite Wells, 8.9 miles north of, 20 feet east of road; iron post stamped "B 2370 1907"-----	2, 270. 292
Granite Wells, 12.2 miles north of, 20 feet east of road; iron post stamped "2276 B 1907"-----	2, 175. 828
Lone Willow, 10 miles south of, 15.3 miles north of Granite Wells, 20 feet east of road; iron post stamped "B 2203 1907"-----	2, 103. 810
Lone Willow, 6 miles south of, 20 feet east of road; iron post stamped "2121 B 1907"-----	2, 021. 245
Lone Willow, 2.6 miles east of, at junction of road to Lone Willow; iron post stamped "2016 1907 B"-----	1, 915. 696
Lone Willow, 2.5 miles north of, 10 feet east of road, large bowlder; aluminum tablet stamped "B 1932 1907"-----	1, 832. 120
Lone Willow, 5.4 miles north of, 20 feet east of road at junction of road to Ballarat; iron post stamped "B 1786 1907"-----	1, 685. 479
Lone Willow, 8.1 miles north of, 200 feet north of large bowlder, 30 feet west of road; iron post stamped "B 1907 1632"-----	1, 631. 582
Lone Willow, 10.1 miles north of, 10 feet east of road; bowlder, tablet stamped "B 1907 1427"-----	1, 427. 216
Lone Willow, 12.7 miles north of, 17.1 miles south of Ballarat, 20 feet east of road; iron post stamped "B 1907 1229"-----	1, 228. 940

	Feet.
Ballarat, 14 miles south of, 20 feet west of road; iron post stamped "B 1907 1098"-----	1, 098. 300
Ballarat, 10.9 miles south of, 20 feet east of road; iron post stamped "B 1907 1059"-----	1, 059. 047
Ballarat, 7.6 miles south of, at junction of road, 10 feet east of road; iron post stamped "B 1907 1051"-----	1, 051. 027

BARSTOW, ALONG BALLARAT ROAD EAST, TO POINT 3.3 MILES EAST OF WINDGATE PASS.

Windgate Pass, at summit, 10 feet east of road, 2.5 miles east of junction of road; iron post stamped "B 1977 1907"-----	1, 976. 778
Windgate Pass, 3.3 miles east of, 20 feet north of road; iron post stamped "B 1925 1907"-----	1, 924. 983

FREEMAN, SOUTHEASTERLY TO RANDSBURG; THENCE EASTERLY TO GRANITE WELLS.

Freeman, 400 feet south of, 20 feet west of road, on hillside, south side of Walker Canyon; iron post stamped "3379 B"-----	3, 381. 335
Freeman, 5 miles east of, 150 feet north of road, on point 300 yards west of wash, 10 feet east of section corner, large boulder; tablet stamped "B 2705 1907"-----	2, 706. 763
Freeman, 123 miles east of, 30 feet south of road, ledge; tablet stamped "B 2975 1907"-----	2, 977. 063
Willow Springs, at summit of divide south of, 15 feet west of road, 10 feet from granite boulder; iron post stamped "J 4116"-----	4, 109. 639
Garden station, 3.3 miles south of, at junction of road to Willow Springs, 300 feet west of road; volcanic boulder; aluminum tablet stamped "B 3512 1907"-----	3, 513. 244
Randsburg, 5.1 miles north of, 25 feet northwest of junction of Old Borax road to Garlock, 20 feet northwest of road; iron post stamped "3010 J"-----	3, 002. 810
Randsburg, 1.5 feet west of door of butcher shop (stone building), 1 foot above ground; bronze tablet stamped "3530 J"-----	3, 522. 737
Johannesburg, 2.5 feet northwest of platform of station, north side of track; iron post stamped "3544 J"-----	3, 536. 333
Johannesburg, 4.4 miles east of, on summit of divide 20 feet west of road; iron post stamped "3326 J"-----	3, 317. 945
Ts. 29 and 30 S., Rs. 41 and 42 E., 10 feet southeast of common corner; iron post stamped "2823 J"-----	2, 814. 281
Granite Wells, 9 miles southwest of, 30 feet south of Blackwater Well, granite ledge flush with ground; tablet stamped "B 3520 1907"-----	3, 521. 627
Granite Wells, 7.3 miles southwest of, on summit 20 feet north of road, large boulder; tablet stamped "B 3952 1907"-----	3, 952. 817
Granite Wells, 1.5 miles south of, 39.8 miles north of Barstow, 10 feet east of road; point on small boulder painted "3947 USBM"-----	3, 946. 900

FREEMAN, NORTHWEST TO WALKERS PASS.

Walkers Pass, 5 miles southeast of, 50 feet west of road, 200 feet east of spring, granite boulder; aluminum tablet stamped "BB"--	4, 033. 279
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POINT 6.6 MILES NORTH OF MOUNT VERNON MILL, SOUTHWEST TO INDIAN WELLS NORTH OF FREEMAN.

Mount Vernon Mill, 4 miles north of, 350 feet west of spring, 20 feet northwest of road, in top of large granite boulder; bronze tablet stamped "5323 B 1905 24"-----	5, 326. 752
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	Feet.
Mount Vernon Mill, 1.1 miles north of, 5 feet south of road, 40 feet west of Vurless cabin, in large granite bowlder; bronze tablet stamped "4276 B 1905"-----	4, 279. 602
Mount Vernon Mill, 2.25 miles west of, at mouth of Mount Springs Canyon, 20 feet west of road, in large bowlder; bronze tablet stamped "3388 B"-----	3, 392. 108
Mount Vernon Mill, 5.8 miles southwest of, 15 feet west of road, in cropping of granite bowlder; bronze tablet stamped "2631 B"-----	2, 635. 801
Mount Vernon Mill, 8.8 miles southwest of, 25 feet west of road; iron post stamped "2273 B"-----	2, 277. 960
Desert Well, 1 mile east of, 35 feet north of road, in borax flat in ledge; bronze tablet stamped "2199 B"-----	2, 203. 775
Desert Well, 2 miles south of, 100 feet east of road, on south side of dry lake; iron post stamped "2209 B"-----	2, 214. 008
Desert Well, 5.2 miles southwest of, 50 feet east of road; iron post stamped "2225 B"-----	2, 229. 966
Indian Wells, 5.5 miles northeast of, 30 feet east of road, in alkali flat; iron post stamped "2236 B"-----	2, 241. 178
Indian Wells, 2.5 miles north of, 15 feet west of road; iron post stamped "2402 B"-----	2, 407. 195
Indian Wells, 300 feet north of, 10 feet west of road; iron post stamped "F 16"-----	2, 740. 161

RANDSBURG 15' QUADRANGLE (PILOT PEAK 1° QUADRANGLE).

JOHANNESBURG WEST TO RANDSBURG.

Johannesburg, in front of station; top of rail-----	3, 537. 3
Johannesburg, 25 feet northwest of platform of station, north side of track; iron post stamped "3544 J" (recovered by Biggs, 1907)-----	3, 536. 333
Randsburg, 1.5 feet west of door of butcher shop (store building), 1 foot above ground; bronze tablet stamped "3530 J" (recovered by Biggs, 1907)-----	3, 522. 737

RANDSBURG, NORTH TO GARDEN STATION.

Randsburg, 5.1 miles north of, 25 feet northwest of junction of old borax road to Garlock, 20 feet northwest of road; iron post stamped "3010 J" (recovered by Biggs, 1907)-----	3, 002. 810
Garden station, 1 mile northeast of, sec. 18, T. 28 S., R. 41 E., Mount Diablo meridian, 50 feet northwest of road, 4 feet east of northwest corner of section; iron post stamped "3024 J." (This bench mark is north of Randsburg 15' quadrangle on Pilot Peak, 1° quadrangle)-----	3, 016. 325

IN T. 28 S., R. 40 E., NORTHWEST TO SUMMIT OF DIVIDE SOUTH OF WILLOW SPRINGS.

T. 28 S., R. 40 E., sec. 34, 300 feet west of junction of roads, in volcanic bowlder; aluminum tablet stamped "3512 B 1907" (set by Biggs, 1907)-----	3, 513. 244
Willow Springs, at summit of divide south of, 15 feet west of road 10 feet from granite bowlder; iron post stamped "4116 J" (recovered by Biggs, 1907)-----	4, 109. 639

GARDEN STATION, SOUTH VIA SUMMIT DIGGINGS, TO JOHANNESBURG.

Little Dry Lake, summit of divide at south end of, 30 feet east of road; iron post stamped "3220 J"-----	3, 212. 190
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RANDSBURG, SOUTHEAST TO BLACK HAWK MINE; THENCE NORTH TO JOHANNESBURG.

	Feet.
Black Hawk Mine, on ridge 750 feet north of, 30 feet north of road and 50 feet from junction with road to Stringer; iron post stamped 3706 J "-----	3, 698. 691

JOHANNESBURG, EAST VIA SKILLING WELLS ROAD, TO TOWNSHIP CORNER; THENCE NORTH-EAST TO SOUTHWEST CORNER SEC. 29, T. 29 S., R. 42 E.

Johannesburg, 4.4 miles east of, on summit of divide 20 feet west of road; iron post stamped "3326 J" (recovered by Biggs, 1907)-----	3, 317. 945
T. 30 S., R. 42 E., 10 feet southeast of northwest corner sec. 6; iron post stamped "2823 J" (recovered by Biggs, 1907)-----	2, 814. 281
T. 29 S., R. 42 E., 5 feet northeast of southwest corner sec. 29; iron post stamped "2812," (single spur)-----	2, 803. 223

JOHANNESBURG, SOUTH ALONG LINE OF RANDSBURG RAILROAD (SINGLE SPUR LINE).

St. Elmo, 50 feet west of switch stand, iron post stamped "3184 J."-----	3, 176. 109
St. Elmo, 3.84 miles south of, 30 feet west of track; iron post ^a stamped "2984 J"-----	2, 975. 880

QUADRANGLE EAST OF PILOT PEAK.

NEAR WINDGATE PASS, NORTHEASTERLY TO POINT 22 MILES FROM WINDGATE PASS.

Windgate Pass, 6.3 miles east of, 50 feet east of road, large boulder; tablet stamped "B 1863 1907"-----	1, 863. 300
Windgate Pass, 9.6 miles east of, 20 feet east of road; iron post stamped "B 1730 1907"-----	1, 730. 316
Windgate Pass, 13.3 miles northeast of, 30 feet east of road; iron post stamped "B 1610 1907"-----	1, 609. 840
Windgate Pass, 15.5 miles northeast of, 20 feet east of road; iron post stamped "B 1907 1278"-----	1, 278. 004
Windgate Pass, 17.5 miles northeast of, 10 feet east of road, boulder; tablet stamped "B 1907 930"-----	929. 394
Windgate Pass, 21.1 miles north of, 200 feet north of road, large boulder; aluminum tablet stamped "B 1907 480"-----	479. 238

FURNACE CREEK 1° QUADRANGLE.

POINT 22 MILES NORTHEAST OF WINDGATE PASS, NORTH THROUGH DEATH VALLEY, TO STATE LINE NEAR DAYLIGHT SPRINGS.

Bennett's well, 16 miles south of, 20 feet east of road; iron post stamped "B 1907 -215"-----	-215. 156
Bennett's well, 13.1 miles south of, 20 feet east of road; iron post stamped "B 1907 -224"-----	-224. 676
Bennett's well, 10 miles south of, 20 feet east of road; iron post stamped "B 1907 -235"-----	-235. 087
Bennett's well, 7.2 miles south of, 40 feet east of Mesquite Wells; iron post stamped "B 1907 -244"-----	-224. 460
Bennett's well, 4.2 miles south of, 20 feet east of road; iron post stamped "B 1907 -248"-----	-248. 546
Bennett's well, 20 feet east of; iron post stamped "B 1907 -276"-----	-266. 393
Bennett's well, 3.5 miles north of, 20 feet east of road; iron post stamped "B 1907 -260"-----	-250. 230
Bennett's well, 7 miles north of, 20 feet east of road; iron post stamped "B 1907 -253"-----	-243. 929

^a This bench mark is south of Randsburg 15' quadrangle on Pilot Peak 1° quadrangle.

	Feet.
Bennett's Well, 10.1 miles north of, 20 feet east of road; iron post stamped "B 1907 —263"-----	—253. 412
Furnace Creek ranch, 8.6 miles south of, 20 feet east of road, in borax flat; iron post stamped "B 1907 —284"-----	—274. 180
Furnace Creek ranch, 5.9 miles south of, 20 feet east of road; iron post stamped "B 1907 —233"-----	—223. 173
Furnace Creek ranch, 2.8 miles south of, 20 feet west of road; iron post stamped "B 1907 —227"-----	—217. 576
Furnace Creek ranch, 300 feet south of house at road forks; iron post stamped "B 1907 —188"-----	—178. 357
Furnace Creek ranch, 4.6 miles north of, 20 feet east of road; iron post stamped "B 1907 —262"-----	—253. 389
Furnace Creek ranch, 7.4 miles north of, 400 feet west of road; stone monument (corner of North Coleman borax deposit), top painted "USBM —261"-----	—251. 44
Furnace Creek ranch, 8.6 miles north of, 20 feet east of road; iron post stamped "B 1907 —258"-----	—248. 608
Furnace Creek ranch, 12.4 miles north of, 60 feet north of road; iron post stamped "B 1907 1"-----	10. 753
Furnace Creek ranch, 16 miles north of, 50 feet east of road, sandstone ledge; aluminum tablet stamped "B 1907 669"-----	678. 290
Furnace Creek ranch, 21 miles north of, at junction of road to Stovepipe, 20 feet east of road, rock ledge; aluminum tablet stamped "B 1907 2253"-----	2, 263. 047
Daylight Springs, 3.5 miles south of, 20 feet east of road, rock ledge; aluminum tablet stamped "B 1907 3117"-----	3, 127. 138
Daylight Springs, 0.2 mile east of, on summit 20 feet east of road; iron post stamped "B 1907 4307"-----	4, 317. 380

ROAD FORK 11 MILES NORTH OF FURNACE CREEK RANCH, NORTHWEST 11 MILES TOWARD STOVEPIPE.

Furnace Creek ranch, 12 miles north of, 9 miles southeast of Stovepipe, 20 feet east of road; iron post stamped "B 1907 —231"-----	—231. 630
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STATE LINE, WEST TO FURNACE CREEK RANCH.

Kings Springs, 12 miles west of, at junction of roads; iron post stamped "B 1907 2101"-----	2, 101. 736
Kings Springs, 13.2 miles west of, 1.7 miles north of Nelson's mill No. 2, 20 feet west of road; iron post stamped "B 1907 2117"-----	2, 117. 545
Nelson's well No. 2, 200 feet west of; iron post stamped "B 1907 2180"-----	2, 179. 977
Nelson's well No. 2, 4.5 miles west of, 20 feet south of road; iron post stamped "B 1907 2572"-----	2, 572. 655
Summit, 1.5 miles east of, 20 feet south of road, bowlder; aluminum tablet stamped "B 1907 2864"-----	2, 864. 839
Summit, 20 feet south of road; iron post stamped "B 1907 3041"-----	3, 041. 742
Smith Tank, 5.6 miles east of, 20 feet south of road, rock ledge; aluminum tablet stamped "B 1907 2701"-----	2, 701. 536
Smith Tank, 1.4 miles east of, at junction of Greenwater road, 20 feet north of road; iron post stamped "B 1907 1938"-----	1, 939. 069

	Feet.
Smith Tank, 2.1 miles west of, 8.1 miles east of Furnace Creek, 30 feet south of road, bowlder; aluminum tablet stamped "B 1907 1330"-----	1, 331. 062
Furnace Creek, 2.5 miles east of, at spring (head of Furnace Creek), 40 feet north of road; iron post stamped "B 1907 283"-----	283. 463

BALLARAT 1° QUADRANGLE.

BENCH MARK ON FURNACE CREEK QUADRANGLE (9 MILES SOUTHEAST OF STOVEPIPE), NORTH-WEST VIA STOVEPIPE, TO MESQUITE SPRING.

Stovepipe, 6.3 miles southeast of, on summit 20 feet east of road; iron post stamped "B 1907 —68"-----	—68. 098
Stovepipe, 3.6 miles southeast of, 20 feet north of road; iron post stamped "B 1907 —90"-----	—90. 741
Stovepipe, 150 feet east of store, at junction of roads; iron post stamped "B 1907 —49"-----	—49. 118
Stovepipe, 3.3 miles northwest of, 30 feet east of road; iron post stamped "B 1907 —13"-----	—13. 539
Stovepipe, 5.6 miles northwest of, 20 feet west of road, bowlder; tablet stamped "B 1907 —29"-----	—29. 794
Surveyors Well, 7.5 miles north of, 1.2 miles south of Lost Wagons; 50 feet east of road, large white bowlder; aluminum tablet stamped "B 1907 +373"-----	372. 700
Mesquite Spring, 400 feet south of, at junction of roads, bowlder; tablet stamped "B 1907 1739"-----	1, 738. 824

STOVEPIPE, SOUTHWEST TO EMIGRANT WASH; THENCE SOUTH TO BALLARAT.

Stovepipe, 2.5 miles southwest of, 20 feet north of road; iron post stamped "B 1907 —46"-----	—46. 078
Stovepipe, 6.3 miles southwest of, 20 feet north of road; iron post stamped "B 1907 0000"-----	—0. 566
Stovepipe, 9.6 miles southwest of, 20 feet north of road; iron post stamped "B 1907 637"-----	636. 331
Stovepipe, 12.5 miles southwest of, 6.7 miles north of, Emigrant Spring, 20 feet north of road; iron post stamped "B 1907 1542"---	1, 541. 757
Emigrant Spring, 4.2 miles north of, 20 feet north of road; iron post stamped "B 1907 2380"-----	2, 379. 264
Emigrant Spring, 1.7 miles north of, 40 feet east of road; iron post stamped "B 1907 3199"-----	3, 198. 574
Emigrant Spring, 100 feet south of restaurant at station; iron post stamped "B 1907 4046"-----	4, 045. 131
Emigrant Spring, 4.3 miles south of, 3.1 miles north of Summit, 20 feet east of road; iron post stamped "B 1907 4899"-----	4, 898. 715
Summit between Death and Panamint valleys, 20 feet west of road; iron post stamped "B 1907 5321"-----	5, 320. 034
Summit, 2.9 miles southwest of, 5.6 miles east of Wild Rose, 20 feet north of road; iron post stamped "B 1907 5021"-----	5, 020. 272
Wild Rose, 2.2 miles north of, 20 feet west of road; iron post stamped "B 1907 4462"-----	4, 461. 826
Wild Rose, 20 feet west of road; iron post stamped "3617 B 1907"---	3, 616. 896
Wild Rose, 3 miles south of, 14.7 miles north of Ballarat, 20 feet east of road; iron post stamped "B 1907 2496"-----	2, 495. 772

	Feet.
Ballarat, 11.7 miles north of, 20 feet west of road; iron post stamped " B 1907 1989 "-----	1, 988. 023
Ballarat, 8.2 miles north of, 200 feet south of well; iron post stamped " B 1907 1104 "-----	1, 103. 198
Ballarat, 4 miles north of, 20 feet east of road; iron post stamped " B 1907 1082 "-----	1, 080. 982
Ballarat, 300 feet north of post-office, large bowlder; aluminum tablet stamped " KEELER 1906 1069 "-----	1, 060. 587
Ballarat, in front of post-office; iron post stamped " 1066 "-----	1, 066. 729

BALLARAT, SOUTH 3.8 MILES.

Ballarat, 1.6 miles south of, 20 feet east of road, bowlder; aluminum tablet stamped " B 1907 1054 "-----	1, 054. 200
Ballarat, 3.8 miles south of, 20 feet east of road; iron post stamped " B 1907 1049 "-----	1, 049. 193

KEELER, SOUTHEAST ALONG ROAD, TO DARWIN.

Keeler, 3.4 miles southeast of, 25 feet east of road; iron post stamped " 3629 B "-----	3, 631. 009
Keeler, 6.4 miles southeast of, 80 feet northeast of road, dark volcanic bowlder; aluminum tablet stamped " 3923 B "-----	3, 924. 927
Keeler, 9.6 miles southeast of, 0.5 mile south of summit, 25 feet east of road, volcanic bowlder; aluminum tablet stamped " 4298 B "-----	4, 299. 545
Keeler, 12.8 miles southeast of, 1,000 feet east of stone corral, 20 feet north of road; iron post stamped " 4551 B "-----	4, 553. 026
Darwin, 8.4 miles northwest of, 25 feet north of road, black volcanic bowlder; aluminum tablet stamped " 4878 B "-----	4, 880. 389
Darwin, 5.3 miles northwest of, 25 feet south of road; iron post stamped " 5269 B 1905 "-----	5, 290. 907

DARWIN, SOUTH AND SOUTHWEST VIA COSO HOT SPRINGS, TO LITTLE LAKE (A POINT ON FARMER'S PRECISE LINE).

Darwin, 2 feet from southeast corner of post-office; iron post stamped " 4746 B "-----	4, 748. 596
Darwin, 2.5 miles south of, 25 feet west of road, 15 feet west of pipe line, granite rock; aluminum tablet stamped " 4787 B "-----	4, 789. 915
Darwin, 5.7 miles south of, 25 feet west of road, granite bowlder; aluminum tablet stamped " 5425 B "-----	5, 427. 476
Coso, 200 feet north of, 200 feet north of spring, 200 feet northwest of road, summit of cliff of bowlders; aluminum tablet stamped " 5829 B "-----	5, 831. 378
Coso, 2.8 miles southwest of, 1,700 feet north of Cole Spring, 25 feet south of road, granite bowlder; aluminum tablet stamped " 6413 B "-----	6, 415. 332
Coso, 6.6 miles southwest of, 20 feet west of road, on summit west of volcanic mountain, volcanic rock; aluminum tablet stamped " 6251 B "-----	6, 253. 873
Coso Hot Springs, 3.3 miles northeast of, 40 feet west of road at east side of large gulch, granite bowlder; aluminum tablet stamped " 4398 B "-----	4, 392. 066
Coso Hot Springs, 1,000 feet west of, granite rock; aluminum tablet stamped " 3632 B "-----	3, 634. 850

	Feet.
Coso Hot Springs, 4.1 miles west of, 20 feet south of road, at top of steep pitch volcanic rock; aluminum tablet stamped "4059 B"-----	4, 061.598
Coso Hot Springs, 8 miles west of, 60 feet southeast of road, opposite small crater, granite boulder; aluminum tablet stamped "3406 B"-----	3, 408.636
Little Lake, 1.7 miles north of, 50 feet west of road, summit of boulder; aluminum tablet-----	3, 329.511
DARWIN, SOUTH ALONG ROAD, TO POINT 5 MILES SOUTH OF MILLSPAUGH; THENCE SOUTH 6 MILES TO POINT 6.6 MILES NORTH OF MOUNT VERNON.	
Darwin, southwest corner of post-office; iron post stamped "4746 B"-----	4, 748.596
Darwin, 3 miles southeast of, 15 feet west of road, granite boulder; aluminum tablet stamped "4463 B"-----	4, 465.944
Darwin, 6.4 miles southeast of, 25 feet east of road at junction; iron post stamped "4446 B"-----	4, 449.055
Darwin, 10.5 miles southeast of, 25 feet east of road, granite boulder; aluminum tablet stamped "4815 B"-----	4, 818.215
Darwin, 12.3 miles southeast of, 20 feet west of road, granite boulder; bronze tablet stamped "5324 B"-----	5, 327.071
Darwin, 15 miles southeast of, 60 feet west of Frank Steward's house; iron post stamped "5722 B"-----	5, 725.383
Mount Vernon Mill, 12.4 miles north of, 5 miles west of Millspaugh, 25 feet east of road; iron post stamped "5685 B 1905"-----	5, 688.170
Mount Vernon Mill, 9.3 miles north of, 50 feet west of road, in large granite boulder; bronze tablet stamped "5842 B 1905"-----	5, 845.037
Mount Vernon Mill, 6.6 miles north of, 15 feet east of road, near summit, in large granite boulder; bronze tablet stamped "5884 B"-----	5, 887.468
FIVE MILES WEST OF MILLSPAUGH, EAST ALONG STAGE ROAD VIA MILLSPAUGH, TO BALLARAT.	
Millspaugh, 1 mile west of, 20 feet south of road, in large boulder; aluminum tablet stamped "6073 KEELER"-----	6, 074.448
Millspaugh, 100 feet west of post-office, 75 feet south of well, in large outcropping boulder; aluminum tablet stamped "6157 KEELER"-----	6, 157.805
Millspaugh, 3 miles southeast of, 0.2 mile east of spring and stage station, 12 feet north of road, in top of granite boulder; bronze tablet stamped "4857 KEELER"-----	4, 858.355
Millspaugh, 5.5 miles southeast of, in canyon 100 feet west of high black cliff, in large outcropping boulder; aluminum tablet stamped "3517 KEELER"-----	3, 517.921
Ballarat, 8.7 miles northwest of, on broad slope overlooking Ballarat and Panamint valleys, below mouth of Shepherds Canyon, 20 feet north of road, in large granite boulder; aluminum tablet stamped "2460 KEELER 1905"-----	2, 461.208
Ballarat, 4.6 miles west of, 15 feet north of road, in outcropping boulder; aluminum tablet stamped "1387 KEELER"-----	1, 389.160
Ballarat, 2.4 miles west of, 40 feet west of junction of Ballarat and Bullfrog roads, in large borax flat; iron post stamped "KEELER 1045"-----	1, 045.741
Ballarat, 300 feet north of post-office, 20 feet north of road, in large outcropping boulder; aluminum tablet stamped "1069 KEELER"-----	1, 069.528
Ballarat, 20 feet south of post-office; iron post stamped "1066 KEELER" set in cubic yard of concrete-----	1, 066.222

MESQUITE SPRINGS NORTH TO STATE LINE MONUMENT NO. 82.

	Feet.
Mesquite Springs, 4.8 miles north of, opposite Grapevine Springs, 20 feet west of road, large boulder; tablet stamped "B 1907 2078"---	2, 078. 164
Sand Spring, 50 feet southwest of, boulder flush with ground; tablet stamped "B 1907 3127"-----	3, 127. 681
Sand Spring, 4 miles north of, 200 feet east of road; California-Nevada State-line monument No. 82, top of painted post-----	3, 741. 714
Sand Spring, 4 miles north of, State-line monument No. 82, on boulder; tablet stamped "B 1907 3739"-----	3, 739. 866

KERNVILLE AND OLANCHA QUADRANGLES.

INYO, KEEN, AND TULARE COUNTIES.

The elevations in the following list are based upon precise levels run in 1905 from Mohave north along stage road to Keeler, thence north along Carson and Colorado Railway, and also upon a bench mark at Caliente. The bench marks at Mohave and Caliente are on a precise-level line of 1902, and the heights now accepted are derived by an adjustment of this line made in January, 1907, taking into account rod error discovered upon rerunning, and precise leveling of 1906 from San Diego to Mohave, the new value at Mohave being 2 feet higher than that formerly accepted.

The leveling along the Kern Valley is the result of a single primary line run in 1905 by Mr. C. H. Semper, levelman, corrected for rod error by 0.0004 foot per vertical foot decreasing differences and bearing no other adjustment except to spur west from mouth of Coyote Creek to Hackett trail, Kaweah quadrangle, on account of a remaining closure of +1.8 feet and to the section north from Coyote Creek to Mount Whitney on account of a closure of -1.5 feet on the mean results of Farmer's and Shannon's primary lines from Mount Whitney station.^a

The other leveling on Olancha quadrangle, from Olancha north, was done in 1905 by Mr. L. F. Biggs, levelman, and that on Kernville quadrangle east from Isabella to Walkers Pass was done in 1906 by Mr. Biggs. The work was all done under the direction of Mr. R. B. Marshall, geographer.

The standard bench marks are stamped with the year and figures of elevation as determined when the line was run, which are mostly incorrect.

^a The bench marks of Semper's line falling upon other quadrangles are elsewhere inserted as follows: Caliente (p. 104), Greenhorn (p. 103), Kaweah (p. 107), and Mount Whitney (p. 99).

OLANCHA QUADRANGLE.

OLANCHA, NORTH ALONG ROAD ON WEST SIDE OF OWENS LAKE, TO POINT 8 MILES SOUTH OF LONE PINE.

	Feet.
Olancha, in front of post-office; iron post stamped "F 31"-----	3, 649. 391
Olancha, 4 miles north of, top of hill 20 feet west of road, granite boulder; aluminum tablet stamped "3644 B"-----	3, 642. 661
Cottonwood, 1 mile south of, 40 feet east of road, granite boulder; aluminum tablet stamped "3678 B"-----	3, 676. 092
Lone Pine, 14 miles south of, 2 miles north of Cottonwood, top of hill, 40 feet west of road, in rock; aluminum tablet stamped "3750 B"-----	3, 748. 490
Lone Pine, 11 miles south of, 50 feet east of road, granite boulder; aluminum tablet stamped "3691 B"-----	3, 689. 402
Lone Pine, 8 miles south of, 50 feet west of road at top of hill, granite boulder; aluminum tablet stamped "3691 B"-----	3, 689. 580

ROCK CREEK, SOUTH ALONG KERN RIVER, TO COYOTE CREEK.*

Rock Creek, 100 feet south of, at top of bank of creek, west margin of trail, large rock; aluminum tablet stamped "6966 G 1905 5S"---	6, 969. 098
Big Arroyo, 125 feet south of, 10 feet west of trail, 15 feet west of 4-foot cedar tree, large rock; aluminum tablet stamped "6662 G 1905 4 S"-----	6, 664. 410
Kern River, junction of trail down Coyote Creek with trail along Kern River, 60 feet south of Coyote Creek, west face of large gran- ite rock; aluminum tablet stamped "6456 G 1905 3 S"-----	6, 458. 117

COYOTE CREEK, SOUTH ALONG KERN RIVER, TO TROUT MEADOW; THENCE WEST ALONG JORDAN TRAIL TO LLOYD; THENCE VIA LOWER PEPPERMINT MEADOWS AND SUCKER FLAT, TO DRY MEADOWS.

Kern Lake, surface of water, August, 1905-----	6, 232. 7
Coyote Creek, 5.3 miles south of, 100 feet north of foot of hill leading up to Trout Meadow, 600 feet south of stone wall fence across trail, in rock ledge; aluminum tablet stamped "5786 G 1905 1 S"-----	5, 788. 933
Trout Meadow, at junction of trail to Kern Flat and trail to Dry Meadows, 275 feet north of McIntyre's cabin, 25 feet east of trail, west face of large rock; aluminum tablet stamped "6119 G 1905 2 S"-----	6, 121. 123
Little Kern River, 2.8 miles south of, 750 feet south of summit of mountain, 20 feet west of trail, leading down to Lloyds Meadow, in face of large rock; aluminum tablet stamped "6839 G 1905"---	6, 841. 084
Lloyds Meadow, at Soda Spring, top of rock over Soda Water Flow; aluminum tablet stamped "5527 G 1905 4 S"-----	5, 529. 571
Lower Peppermint Meadow, southeast end of trail which enters small dry canyon and dense scrub oak, 15 feet west of trail, face of large rock; aluminum tablet stamped "5196 G 1905 5 S"-----	5, 198. 64
Dry Meadows, at south end of, 20 feet east of trail leading to Mat Flynn Canyon, 160 feet north of trail crossing Dry Meadow Creek, west face of very large granite rock; aluminum tablet stamped "4341 G 1905 6 S"-----	4, 344. 20

* Line crosses Kern River at south end of Upper Funston.

KERN RIVER, WEST VIA COYOTE AND RIFLES CREEKS, TO GREAT WESTERN DIVIDE.

	Feet.
Great Western Divide, at summit, trail leading south, top of large rock; aluminum tablet stamped "10033 G 1905 2 S"-----	10, 033. 664

KERNVILLE QUADRANGLE.

DRY MEADOW, SOUTH VIA ANGEL CAMP AND KERN RIVER, TO FAIRVIEW; THENCE ALONG TRAIL AND HIGHWAY FOLLOWING KERN RIVER, TO HAVILAH.

Kern River, junction of second Dry Meadow Creek with Kern River, 230 feet north of junction, in north wall of dry creek; aluminum tablet stamped "3765 G 1905 7 S"-----	3, 768. 028
Fairview, 150 feet directly east of Fairview Camp, 40 feet east of top of river bank, top of large granite boulder; aluminum tablet stamped "3516 G 1905 8 S"-----	3, 519. 659
Kern River, 3 miles south of, 0.5 mile north of old corral, 25 feet east of trail, northwest face of large rock, 8 by 8 by 7 feet; aluminum tablet stamped "3122 G 1905 9 S"-----	3, 126. 051
Kernville, 6.3 miles north of, at Chico ranch, 85 feet south of south margin of house, 30 feet west of fence, 15 feet north of ditch, north face of large rock; aluminum tablet stamped "2767 G 1905 10 S"-----	2, 771. 192
Kernville, 3.1 miles north of, 960 feet south of Frank Apalatea's ranch, on west margin of road, 15 feet west of fence line, 55 feet north of fence corner, top of rock; aluminum tablet stamped "2631 G 1905 11 S"-----	2, 634. 920
Kernville, southeast corner of A. Brown & Co.'s store; aluminum tablet stamped "2565 G 1905 12 S"-----	2, 569. 015
Hot Springs, 1.9 miles south of, Kern River Flume, north end of concrete bent foundation east margin of road; aluminum tablet stamped "2487 G 1905 14 S"-----	2, 491. 264

ISABELLA, EAST VIA ONYX, TO WALKER PASS.

Isabella, on road to Death Valley, 105 feet northeast of northeast corner of Methodist Church, 8 feet north of road, top of large rock; aluminum tablet stamped "G 1905 13 2521" (Semper's)-----	2, 525. 326
Isabella, 3 miles east of, sec. 22, T. 26 S., R. 33 E., 20 feet south of road at rocky point, slate ledge; aluminum tablet stamped "B. R. 1906 1 2554"-----	2, 555. 587
Isabella, 7 miles east of, sec. 20, T. 26 S., R. 34 E., 2 feet north of fence south of road, 1,000 feet east of cottonwood trees, granite rock, flush with ground; aluminum tablet stamped "B. B. 2 2617"-----	2, 618. 291
Isabella, 9 miles east of, sec. 22, T. 26 S., R. 34 E., 1.2 miles west of Weldon, 250 feet north of cemetery, 10 feet north of road, granite boulder; aluminum tablet stamped "B. B. 1906 3 2635"-----	2, 637. 024
Weldon, 2.6 miles east of, sec. 18, T. 26 S., R. 35 E., 10 feet east of road, in saddle west of rocky point, in granite boulder; aluminum tablet stamped "B. B. 1906 4 2686"-----	2, 688. 367
Onyx, 0.8 mile east of, sec. 4, T. 26 S., R. 35 E., 100 feet east of northeast corner of field, 20 feet south of road, granite rock; aluminum tablet stamped "B. B. 1906 5 2746"-----	2, 747. 971
Onyx, 7 miles east of, sec. 30, T. 25 S., R. 36 E., opposite Power's house, 20 feet south of road, in granite rock; aluminum tablet stamped "13 B 1906 6 2893"-----	2, 895. 527

	Feet.
Onyx, 9.2 miles east of, near quarter corner east side of sec. 29, T. 25 S., R. 36 E., 10 feet south of road, granite bowlder; aluminum tablet stamped "B. B. 1906 7 3145"-----	3, 147. 096
Onyx, 12 miles east of, sec. 23, T. 25 S., R. 36 E., 0.5 mile north of canebrake, on grade 20 feet west of road in canyon, granite rock; aluminum tablet stamped "B. B. 1906 8 3745"-----	3, 746. 956
Onyx, 15 miles east of, near southeast corner sec. 36, T. 25 S., R. 36 E., east side of creek, 20 feet east of forks of road, granite rock; aluminum tablet stamped "B. B. 1906 9 4327"-----	4, 329. 372
Walker Pass, summit of, sec. 17, T. 26 S., R. 37 E., 18 miles east of Onyx, 15 feet east of road, granite rock; aluminum tablet stamped "B. B. 1906 10 5245"-----	5, 248. 321

BISHOP, LONG VALLEY, MOUNT GODDARD, AND MOUNT WHITNEY QUADRANGLES.

INYO, MONO, AND TULARE COUNTIES.

The elevations in the following list are based upon precise leveling by R. A. Farmer, in 1905, corrected to accord with an elevation at Mohave determined by an adjustment made in January, 1907. Additional elevations on Bishop and Mount Whitney quadrangles on precise lines, Mohave to Laws and Alvord to Oasis are given in another list, pages 11-12.

The leveling was done in 1905 under Mr. R. B. Marshall, geographer, mostly by Mr. L. F. Biggs, levelman. The work on Mount Whitney quadrangle includes a double line from Mount Whitney station west to summit of Mount Whitney run by Messrs. R. A. Farmer, topographer, and M. D. Shannon, levelman, and a single line thence to and down the Kern River run by Mr. C. H. Semper, levelman. The work on Long Valley quadrangle includes work of 1898 by Mr. C. R. Smith, levelman.

MOUNT WHITNEY QUADRANGLE.

MOUNT WHITNEY STATION, WEST ALONG WAGON ROAD AND TRAIL TO SUMMIT OF MOUNT WHITNEY.

	Feet.
Mount Whitney station, southeast corner of, spike in base of telegraph pole. (This from precise line from Keeler to Law)-----	3, 689. 754
Lone Pine, in front of post-office; iron post stamped "3728 B 1905"-----	3, 726. 617
Stone House, 200 feet south of, southwest of creek, granite bowlder, 20 by 8 by 7 feet, 10 feet south of road; aluminum tablet stamped "4519 B 1905"-----	4, 518. 188
Lone Pine Creek canyon, mouth of, 400 feet east of falls, south of trail, in face of rock 20 by 10 by 6 feet; aluminum tablet stamped "6670 B 1905"-----	6, 668. 877
Hunters Camp ground, 20 feet south or trail, at bottom of steep pitch to the lakes, rock 10 by 6 feet and 5 feet out of ground; aluminum tablet stamped "8373 B 1905"-----	8, 371. 495
Summit of divide of Sierra Nevada Mountains where Lone Pine trail crosses, 20 feet north and west of trail, in granite wall; aluminum tablet stamped "13337 B 1905"-----	13, 335. 095

B. M. No. 35 by Semper, Mount Whitney, on south slope of junction of Lone Pine and Crabtree creeks trail; rock on top, marked "13766"-----	Feet. 13,766.729
Mount Whitney, highest point of summit, in large rock 6.5 feet south and 5 feet west of center of monument; aluminum tablet one-half inch thick, 4.5 inches wide and 7 inches long, engraved as follows: "U. S. Geological Survey, Charles D. Walcott, Director, Latitude 36° 44' 44'', Longitude 118° 17' 29'', Elevation above sea, 14,501, 1905"-----	14,500.737

MOUNT WHITNEY, WEST ALONG TRAIL, TO CRABTREE MEADOW; THENCE NORTHWEST TO KERN RIVER; THENCE SOUTH DOWN KERN RIVER TO ROCK CREEK.

Crabtree Meadow, at junction of trail to Mount Whitney, Kern River, and Whitney Creek, top of very large rock; aluminum tablet stamped "10330 G 1905 7 S"-----	10,332.569
East Fork of Kern River, 2.4 miles north of, on cut-off trail, 30 feet northeast of crossing of small creek, south margin of trail, a north face of large boulder in small meadow; aluminum tablet stamped "9837 1905 6 S"-----	9,838.983

LONE PINE, SOUTH ALONG ROAD 8 MILES.

Lone Pine, in front of post-office; iron post stamped "3727 B"-----	3,726.617
Lone Pine, 5 miles south of, 100 feet south of gulch, 20 feet west of road; iron post stamped "3711 B"-----	3,709.849

LONE PINE, NORTH ALONG ROAD, TO INDEPENDENCE; THENCE EAST TO CITRUS.

Lone Pine, 4 miles north of, 60 feet east of road, granite boulder; aluminum tablet stamped "B"-----	3,723.462
Lone Pine, 7 miles north of, 20 feet east of road; iron post stamped "B"-----	3,811.899
Independence, 5.5 miles south of, 800 feet north of Shepherd's house, 50 feet west of road, in boulder; aluminum tablet stamped "3873 B"-----	3,871.899
Independence, 2 miles south of, top of hill 100 feet west of road, in boulder; aluminum tablet stamped "B"-----	3,941.878
Citrus, in front of station; iron post stamped "F 10"-----	3,766.400

INDEPENDENCE, NORTH ALONG ROAD, TO ABERDEEN.

Independence, in west wall of court-house; aluminum tablet stamped "B"-----	3,924.790
Independence, 4.5 miles north of, 15 feet west of road, 400 feet south of house, granite boulder; aluminum tablet stamped "3891 B"---	3,889.696
Independence, 7.5 miles north of, 20 feet west of road; iron post stamped "3868 B"-----	3,867.352
Independence, 10.5 miles north of, 60 feet west of road; 500 feet north of stream crossing, 0.5 mile west of Eaton's house, in volcanic rock; aluminum tablet stamped "3933 B"-----	3,931.947
Aberdeen, 2.8 miles southwest of, 2 miles north of Eaton's house, east side of road, volcanic rock; aluminum tablet stamped "3864 B"--	3,862.978

BISHOP QUADRANGLE.

NEAR ABERDEEN, NORTH ALONG ROAD, TO BIG PINE; THENCE EAST TO ALVORD.

	Feet.
Big Pine, 12.3 miles south of, 1 mile north of Bower's house, 20 feet west of road, volcanic rock; aluminum tablet stamped "3870 B"---	3,868.581
Big Pine, 7.8 miles south of, under window in front of Fish Spring schoolhouse; iron post stamped "3936 B"-----	3,934.648
Big Pine, 6.3 miles south of, 100 feet west of south end of pond, volcanic rock; aluminum tablet stamped "3888 B"-----	3,887.659
Big Pine, 3.3 miles south of, 500 feet northwest of Rheinacke's house, 150 feet west of road, volcanic rock; bronze tablet stamped "3934 B"-----	3,932.802
Big Pine, 4 feet north of schoolhouse; iron post stamped "4003 B"---	4,002.108
Alvord, in front of station; iron post stamped "F 19"-----	3,930.130

BIG PINE, NORTH ALONG ROAD, TO BISHOP; THENCE EAST TO LAWS.

Big Pine, 2 miles north by 2 miles west of, west side of road at cliff of rocks, bowlder; aluminum tablet stamped "3982 B"-----	3,980.749
Big Pine, 6.5 miles northwest of, near quarter corner east side of sec. 36, T. 8 S., R. 33 E., 60 feet west of road, bowlder; aluminum tablet stamped "4037 B"-----	4,036.016
Valley schoolhouse, 3.5 miles north of, common corner of secs. 32 and 33, T. 7 S., and secs. 4 and 5, T. 8 S., R. 34 E., 0.25 mile south of Butler schoolhouse, 600 feet west of road; iron post stamped "4046"-----	4,045.236
Bishop, 2 miles south by 1 mile west of, 300 feet west of canal, at stone post; iron post stamped "4319 B"-----	4,318.783
Bishop, Fred. H. Bulpitt's store, under front window, in stone wall; aluminum tablet stamped "4148 B"-----	4,147.311
Laws, 100 feet east of station; iron post stamped "25 F"-----	4,114.583

MOUNT GODDARD QUADRANGLE.^a

WEST AND NORTHWEST OF LAWS.

Laws, 10.7 miles west of, 1,000 feet west of Fred Meger's house, west side of road, granite bowlder; aluminum tablet stamped "B 4422 1905 B 2"-----	4,420.872
Laws, 14 miles northwest of, 2 miles south of Will Robert's ranch, 60 feet west of road, volcanic rock; aluminum tablet stamped "B 1905 B 3 4513"-----	4,511.245

LONG VALLEY QUADRANGLE.^aNORTHWEST OF LAWS TO DEADMAN HILL.^b

Laws, 17 miles northwest of, 1 mile north of Will Robert's house, near Mono-Inyo County line, east side of road, volcanic rock; aluminum tablet stamped "B 1905 14 4698 B"-----	4,696.499
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^a The elevations following on Mount Goddard and Long Valley quadrangles are by a single primary line, unadjusted, making a closure about 6 feet high on elevations brought from Yosemite based upon the same adjusted datum.

^b For closure see Mount Lyell quadrangle, p. 118.

	Feet.
Laws, 21 miles northwest of, summit of Sherwin Hill; 66 feet west of road, volcanic boulder; aluminum tablet stamped "B 1905 B 6432" -----	6, 430. 273
Laws, 24.7 miles northwest of, south end of meadow, 15 feet east of road, 30 feet west of Rock Creek, granite boulder; aluminum tablet stamped "B 1905 6815 B 16" -----	6, 813. 667
Laws, 28.5 miles northwest of, 100 feet north of Crookes Creek, north side of road, 200 feet northeast of forks of road, in volcanic rock; aluminum tablet stamped "B 1905 B 7 6786" -----	6, 764. 867
Laws, 30 miles northwest of, 200 feet east of proposed dam site, north side of river, 20 feet from water, large boulder; aluminum tablet stamped "B 1905 B 8 6668" -----	6, 668. 274
Laws, 34 miles northwest of, 1 mile north of Eaton's house, north side of road, in boulder; aluminum tablet stamped "B 1905 9 6834" --	6, 835. 123
Laws, 37.5 miles northwest of, sec. 13, T. 4 S., R. 24 E., 300 feet north of Summer's gate, 200 feet north of road, large boulder; aluminum tablet stamped "B 1905 10 7066" -----	7, 066. 379
Laws, 41.5 miles northwest of, 1 mile north of Summer's house, 300 feet south of Hot Creek, 100 feet south of road, at point of volcanic boulders; aluminum tablet stamped "B 1905 B 11 7196" -----	7, 196. 987
Laws, 45 miles northwest of, 2 miles northwest of Casa Diablo, 60 feet west of road, boulder; aluminum tablet stamped "B 1905 12 7571" -----	7, 581. 517
Laws, 48.5 miles northwest of, 5.5 miles northwest of Casa Diablo, summit between Hot and Deadman creeks, 200 feet north of road, volcanic rock; aluminum tablet stamped "B 1905 13 7446" -----	7, 657. 043
Laws, 52 miles northwest of, 0.75 mile north of Deadman Creek, west side of road about halfway up Deadman Hill, large boulder; aluminum tablet stamped "B 1905 B 14 7723" -----	7, 733. 896

RUSH CREEK (MONO LAKE), SOUTHEAST TO MONO MILLS; THENCE SOUTHWEST TO CRATER RIDGE.*

Mono Mills road, about 3 miles southeast of where road leaves lake shore, 15 feet to right of road and about 200 feet east of foot of spur of Crater Ridge; iron post stamped "6899 O" -----	6, 910. 057
Mono Mills, in northwest corner post of sawmill; aluminum tablet stamped "7335 O" -----	7, 346. 304
Bodie-Benton wagon road, on summit between Mono Lake and Owens River drainage, 20 feet east of road; iron post stamped "7987 O" --	7, 998. 104

BAKERSFIELD, CALIENTE, FAMOSO, AND GREENHORN 30' QUADRANGLES; BAKERSFIELD SPECIAL AND OIL CENTER SPECIAL QUADRANGLES.

KERN AND TULARE COUNTIES.

The elevations in the following list are based upon a line of precise levels from Benicia along the Southern Pacific Railroad (which traverses all these quadrangles excepting Greenhorn and Oil Center Special) as adjusted in January, 1907.

* Elevations determined from levels run in 1898 by Mr. C. R. Smith, corrected to agree with line from Laws, 6.355 feet greater than as determined from Merced.

Leveling was done on all of the above quadrangles in 1903 by Mr. L. D. Ryus, levelman, and on all except Oil Center Special in 1904 by Mr. S. N. Stoner. Other work was done on Caliente and Greenhorn quadrangles in 1905 by Mr. C. H. Semper, levelman.

The work on Oil Center Special was done under the direction of Mr. A. B. Searle, topographer. The remainder was done under Mr. R. B. Marshall, geographer, in 1903 and 1905, Mr. S. N. Stoner having charge in 1904.

Each of the special maps covers portions of certain of the thirty-minute quadrangles above named, and the bench marks of this list which fall upon them are not separately specified.

BAKERSFIELD 30' QUADANGLE.

KERN, ALONG SUNSET BRANCH OF THE SOUTHERN PACIFIC RAILROAD, RUNNING SOUTHWEST, WEST, AND NORTHWEST, TO SEC. 36, T. 29 S., R. 25 E.

	Feet.
Kern, at station; iron post stamped "B"-----	421. 877
T. 30 S., R. 28 E., sec. 6, southeast corner of, on west side of Union avenue road at crossing, north side of railroad right of way; iron post stamped "392 B"-----	392. 278
T. 30 S., R. 27 E., sec. 15, southeast corner of, 1.68 miles west of Wibble Orchard, at west side of wagon road, at north edge of railroad right of way; iron post stamped "369 B"-----	369. 209
Gosford, in front of station; top of rail-----	362. 0
T. 30 S., R. 27 E., sec. 20, northwest corner of, 1.7 miles west of Gosford, at south side of road, opposite crossing to ranch house; iron post stamped "358 B"-----	358. 551
T. 30 S., R. 26 E., sec. 15, near quarter corner on south side of, 1,200 feet west of milepost 328, north edge of right of way; iron post stamped "346 B"-----	346. 813
T. 30 S., R. 26 E., sec. 7, 1.5 miles west of Stevens, 200 feet south of track, at corner of fence, 500 feet west of milepost 331, 20 feet east of gate; iron post stamped "337 B"-----	337. 748
T. 29 S., R. 25 E., sec. 36, south of northwest corner of, on east side of county road, north edge of railroad right of way; iron post stamped "327 B"-----	327. 610

SUNSET BRANCH, NORTH ALONG WAGON ROAD, TO RIO BRAVO SCHOOL; THENCE EAST TO SANTA FE RAILWAY.

T. 29 S., R. 25 E., sec. 11, near quarter corner on east side of, Rio Bravo schoolhouse, at southeast corner of yard; iron post stamped "332 B"-----	332. 278
T. 28 S., R. 26 E., sec. 32, quarter corner on south side of, opposite north corner common to secs. 4 and 5, T. 29 S., north side of wagon road, at west edge of railroad right of way; iron post stamped "339 B"-----	339. 643

SOUTHEASTERLY ALONG SANTA FE RAILROAD TO KERN.

T. 29 S., R. 26 E., sec. 14, near southeast corner, 0.25 mile east of Rose-dale, 1 mile north of Rosedale post-office, west side of county road, north edge of railroad right of way; iron post stamped "360 B"---	360. 612
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PRIMARY LEVELING.

103

	Feet.
T. 29 S., R. 27 E., sec. 29, quarter corner on east side of, 4 miles west of Bakersfield, west side of public road, north edge of railroad right of way; iron post stamped "387 B"-----	387.366

ONE MILE EAST OF OIL TRIANGULATION STATION, SOUTHWEST ALONG ROAD 3 MILES;
THENCE SOUTHWEST ACROSS COUNTRY TO 1 MILE SOUTHEAST OF JEWETTA.

T. 28 S., R. 27 E., sec. 25, southwest quarter of, Standard Oil Company's storage reservoirs, 1.5 miles north of, east bank of ravine, west side of Bakersfield and Poso Creek road; iron post stamped "730"-----	730.355
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OIL TRIANGULATION STATION, SOUTHWEST ACROSS COUNTRY TO SEC. 14, T. 28 N., R. 27 E.;
THENCE SOUTH TO NEAR JEWETTA.

T. 28 N., R. 27 E., at center of, sec. 14, 2 miles southwest of Oil triangulation station; iron post stamped "864"-----	864.260
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FAMOSO 30' QUADRANGLE.

POSO CREEK STAGE ROAD STATION, WEST DOWN POSO CREEK TO SEC. 29, T. 27 S., R. 27 E.;
THENCE SOUTH TO NEAR JEWETTA.

T. 27 S., R. 28 E., sec. 31, in Poso Creek Valley, 2.8 miles west of stage station, 30 feet south of road, at bend of road; iron post stamped "593 B"-----	593.372
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T. 27 S., R. 27 E., sec. 24, 8 miles north of Jewetta, mouth of drain, on end of spur, north side of road at point where road leaves Poso Creek bottom; iron post stamped "545 B"-----	545.397
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GRANITE CANYON, NORTHWEST ALONG TRAIL AND RIDGE, TO MOUNT POSO (POSO TRIANGULATION STATION); THENCE SOUTH TO POSO CREEK.

Poso triangulation station; iron post stamped "1214 B"-----	1,214.865
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GREENHORN 30' QUADRANGLE.

AT OIL TRIANGULATION STATION.

Oil triangulation station, sec. 7, T. 28 S., R. 28 E.; tablet marking station, stamped "1205"-----	1,205.588
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SEC. 18, T. 28 S., R. 28 E., NORTH ALONG HIGHWAY VIA MON CANYON AND GRANITE CANYON,
TO POINT 2.4 MILES NORTH OF POSO CREEK STAGE STATION.

Poso Creek stage station, 0.2 mile east of, sec. 4, T. 28 S., R. 28 E., 300 feet east of water trough, 30 feet south of road at point where road enters creek bottom, 200 feet west of head of old canal; iron post stamped "633 B"-----	633.176
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T. 27 S., R. 28 E., sec. 22, at fork of Granite Canyon, 2.4 miles north of Poso Creek, 20 feet west of bank; iron post stamped "884 B"-----	884.126
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AT HAVILAH.

Havilah, Havilah Commercial Company building, north end, front face; aluminum tablet stamped "3160 G 1905 15 S"-----	3,164.223
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CALIENTE 30' QUADRANGLE.

HAVILAH, SOUTHWEST ALONG HIGHWAY FOLLOWING KERN RIVER, TO CALIENTE.

	Feet.
Havilah, 4.6 miles south of, 2,400 feet south of summit of mountain, on east margin of road, in small canyon, in large granite rock, west face; aluminum tablet stamped "4072 G 1905 16 S"-----	4, 074. 983
Walkers Basin, 0.8 mile north of, W. Rankin's ranch house, on east side of road, 10 feet west of fence, west face of large rock; aluminum tablet stamped "3335 G 1905 17 S"-----	3, 338. 629
Walkers Basin, 5.5 miles south of, 0.6 mile south of Oak Flat, 100 feet west of loop in road, on south edge of road, top of flat rock; aluminum tablet stamped "2900 G 1905 18 S"-----	2, 903. 822
Caliente, 3 miles northeast of, at fork of road to Pinto and Rankin camps, 10 feet west of road, large rock; aluminum tablet stamped "1534 G 1905 19 S"-----	1, 538. 246
Caliente, 65 feet south of milepost 335, 10 feet east of track; iron post ^a stamped "1201 B"-----	1, 202. 070

KERN, ALONG HIGHWAY NORTH VIA OIL CITY STATION, TO OIL TRIANGULATION STATION.

T. 29 S., R. 28 E., sec. 16, 2.5 miles north of Kern, 100 feet south of edge of mesa, at top of grade of road from Kern to Oil City; iron post stamped "684 B"-----	684. 065
T. 28 S., R. 28 E., sec. 34, at quarter corner on south side of, at corner of fence, west side of road; iron post stamped "522 B"-----	523. 492
T. 28 S., R. 28 E., sec. 21, on ridge about 1 mile north of water tank; iron post stamped "976 B"-----	976. 927
Oil triangulation station, 1 mile southeast of, sec. 18, T. 28 S., R. 28 E., on round knob east of Mon Canyon road; iron post stamped "1133"-----	1, 132. 894

OIL CITY, NORTHWEST ALONG RAILROAD AND HIGHWAY, TO SEC. 24, T. 28 S., R. 27 E.

Oil Center schoolhouse, in southeast corner of yard; iron post stamped "634 B"-----	634. 123
T. 28 S., R. 28 E., sec. 30, near southeast corner, 1 mile north of Peerless oil claim, on road on ridge north of Stirling oil claim, 100 feet north of house, south side of road; iron post stamped "768"-----	768. 354

POINT 2.5 MILES NORTH OF KERN, SOUTHEAST ALONG SECOND-CLASS ROAD AND ACROSS COUNTRY, TO MILEPOST 320 ON SOUTHERN PACIFIC RAILROAD.

T. 29 S., R. 29 E., sec. 23, 3.5 feet southwest of northeast corner; iron post stamped "829 B"-----	829. 283
Kern, 5 miles east of, sec. 30, T. 29 S., R. 29 E., 2.5 miles north of Southern Pacific Railroad, 20 feet south of road, at point where drain enters flat, east side of mouth of wash; iron post stamped "569 B"-----	569. 471

KAWEAH AND VISALIA QUADRANGLES.

TULARE COUNTY.

The elevations in the following list are based on an iron post 1.4 miles south of Goshen on east side of Southern Pacific Railroad at margin of highway opposite milepost 242, stamped "286 B 1902" established by precise levels run from Benicia, by Mr. C. H. Semper.

^a Elevation adjusted January, 1907.

The leveling was mostly done in 1902 under the direction of Mr. E. C. Barnard, topographer, by Mr. W. V. Hardy, levelman. Additional work was done on both Kaweah and Visalia quadrangles, under Mr. R. B. Marshall, geographer, partly in 1904 and partly in 1905, by Mr. R. A. Farmer, topographer, and on Kaweah quadrangle alone in 1905 by Messrs. M. D. Shannon and C. H. Semper, levelmen.

VISALIA QUADRANGLE.

GOSHEN, EAST VIA SOUTHERN PACIFIC RAILROAD, TO VISALIA.

	Feet.
Goshen, 0.4 mile south of, east side of track, opposite milepost 241; spike in telegraph pole.....	282. 66
Goshen, 3.62 miles east of, about 600 feet south of G. D. Smith's ranch house, 60 feet southeast of crossing, 30 feet south of track, north of road, 3 feet west of telegraph pole; iron post stamped "307 G".....	307. 046
Visalia, court-house, east entrance, at foot of steps; center of the letter "G" in the name "Gay" on cement sidewalk.....	330. 53
Visalia court-house, at east side of steps at south entrance, in granite baluster; aluminum tablet stamped "334 G".....	333. 883

VISALIA, EAST ALONG COUNTY ROAD, TO LEMONCOVE.

Mineral King ranch house, 500 feet west of, northeast angle of road junction near corner fence post; iron post stamped "362 G".....	361. 850
Lemoncove, 8.87 miles west of, 60 feet southwest of crossing, near junction of railroad fence with wagon fence; iron post stamped "388 G".....	388. 028
Lemoncove, 4.76 miles west of, 50 feet southwest of Tom Hushback's ranch house, northeast angle of road junction, 1.5 feet southeast of southwest corner of yard; iron post stamped "420 G".....	419. 845
Lemoncove school, 2 feet east of, midway between north and south entrances; iron post stamped "510 G".....	510. 311

PORTERSVILLE, NORTHWEST ALONG HIGHWAY AND SOUTHERN PACIFIC RAILROAD, TO POINT EAST OF VISALIA.

Portersville school, south side of, 6 inches east of entrance, 12 inches above porch floor; aluminum tablet stamped "458 G".....	458. 104
Sam Bend's saloon, 1.15 miles south of, 70 feet southwest of road intersection, 30 inches east of telephone pole; iron post stamped "396 G".....	396. 431
Lindsay school, south side of, 24 inches east of entrance, 18 inches above ground; aluminum tablet stamped "383 G".....	382. 677
Exeter, 3.25 miles south of, 90 feet north of crossing, 30 inches east of railroad fence, 36 inches southeast of electric power line pole; iron post stamped "353 G".....	352. 697
Exeter school, north of steps at northwest entrance, in west face of granite baluster, 24 inches above ground; aluminum tablet stamped "391 G".....	390. 575
Exeter, in front of station; top of east rail.....	386. 5

CROSSROADS 3 MILES WEST OF LEMONCOVE, SOUTHEAST VIA WAGON ROAD, TO YOKOHL SCHOOL.

James Hamilton's ranch house, 1.21 miles south of, northwest angle of road junction, near corner of fence; iron post stamped "499 G".....	499. 176
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PORTERSVILLE, WEST ALONG HIGHWAY, TO TIPTON.

	Feet.
Portersville, 1 mile south by 1.5 miles west of, south side of road, Percell ranch; iron post stamped "433"-----	432.986
Poplar, 2 miles east of, 4.5 miles west by 1 mile south of Portersville, at southeast corner of road crossing, 8 feet south of telephone pole; iron post stamped "396"-----	396.162
Tipton, 5 miles east of, 4 miles west of Poplar, northwest corner of pasture, southwest corner of road crossing; iron post stamped "328"-----	328.091

KAWEAH QUADRANGLE.

LEMONCOVE, EASTERLY ALONG COUNTY ROAD VIA THREE RIVERS, TO MINERAL KING; THENCE SOUTHEAST ALONG TRAIL OVER FAREWELL GAP, TO WET MEADOWS.

T. 18 S., R. 28 E., sec. 4, 60 feet northeast of Horse Creek bridge, south side of road, 3 feet southwest of oak tree at southwest end of gate on road up Horse Creek; iron post stamped "610 G"-----	609.940
T. 17 S., R. 82 E., sec. 24, 1.42 miles north of Three Rivers post-office, junction of Mineral King and Giant Forest wagon roads, 155 feet southeast of Kaweah River bridge, southeast of junction, granite bed rock, 24 inches above level of road; bronze tablet stamped "816 G"-----	815.701
Three Rivers post-office, 5 miles northeast of, Mount Whitney Company power house, 40 feet east of, north of road, in side of large granite boulder, 30 inches above level of road; bronze tablet stamped "1145 G"-----	1,145.355
Oak Grove telephone station, 120 feet north of, south of road, 30 inches east of gate; iron post stamped "2704 G"-----	2,704.579
Tranger's camp, 100 feet west of stream, north of road, in granite bed rock, 24 inches above level of road; bronze tablet stamped "4595 G"-----	4,594.853
Atwells Mills, 125 feet north of, 45 feet north of skid road, redwood stump 15 feet in diameter; 10-penny wire nail in root-----	6,452.214
Mineral King, 85 feet south of hotel, granite boulder 120 by 180 inches by 30 inches high; bronze tablet stamped "7832 G"-----	7,831.686
Farewell Gap, quartz ledge cropping 30 inches long by 12 inches wide and 8 inches high; bronze tablet stamped "10588 G"-----	10,588.555
Wet Meadows, 120 feet south of junction of trail down Little Kern River with trail to Hacketts Meadow and Quinn's horse camp, 40 feet east of river, 20 feet above stream at trail crossing, west side of trail down river, granite boulder, 30 by 36 by 12 inches; bronze tablet stamped "7924 G"-----	7,923.241

WET MEADOWS, ON LITTLE KERN RIVER, SOUTHWEST ALONG TRAIL VIA ENTERPRISE, TO SPRINGVILLE (DAUNT POST-OFFICE).

Quinn's horse camp, on summit west of, 25 feet northwest of junction of trail to Hacketts Meadow, granite boulder 30 by 30 by 84 inches; bronze tablet stamped "9680 G"-----	9,679.275
Moses Mountain, at east foot of, at junction of trail down North Fork of Middle Fork of Tule River with trail to Enterprise Mill, about 300 feet east of river, 4 feet north of trail, granite boulder 36 by 48 inches and 24 inches high; bronze tablet stamped "6614 G"-----	6,612.749

	Feet.
Enterprise Mill, 0.19 mile east of, on summit 15 feet southeast of road, granite boulder, 48 by 96 inches and 24 inches high; bronze tablet stamped "6652 G"-----	6,651.033
Rancheria, 2.1 miles southeast of creek crossing, junction of road to Coburn dump, 4 feet west of road, 4 feet south of oak tree; iron post stamped "3202 G"-----	3,202.847
T. 20 S., R. 29 E., sec. 14, 2.7 miles south of Milo, 50 feet southwest of junction of road up North Tule River, granite boulder 48 by 144 inches and 18 inches high; bronze tablet stamped "1391 G"-----	1,391.073
Springville, sec. 2, T. 21 S., R. 29 E., north side of school, midway between east and west entrance; iron post stamped "1032 G"-----	1,032.305

SPRINGVILLE, SOUTHWEST ALONG COUNTY ROAD, TO PORTERVILLE.

T. 21 S., R. 29 E., northwest corner of sec. 16, west side of Orange school, midway between north and south entrances; iron post stamped "745 G"-----	745.311
T. 21 S., R. 29 E., west side of sec. 24, 20 feet west of Citrus school, 30 inches south of gate; iron post stamped "622 G"-----	621.896

YOKOHL SCHOOL, EAST UP YOKOHL VALLEY AND OVER GAP, TO MILO.

T. 19 S., R. 27 E., sec. 24, Yokohl school, 70 feet southwest of, 20 feet north of road, embedded granite boulder 36 by 72 inches and 12 inches high; bronze tablet stamped "636 G"-----	636.068
T. 19 S., R. 28 E., sec. 15, about 400 feet north of A. Carlson's ranch house, south of road, 30 inches east of gate; iron post stamped "991 G"-----	991.252
Blue Ridge, south end of, 15 feet north of road, summit on road, granite ledge; bronze tablet stamped "2675 G"-----	2,675.061

THREE RIVERS POST-OFFICE, SOUTH ALONG COUNTY ROAD TO CINNAMON SCHOOL (SINGLE SPUR LINE).

Cinnamon school, 50 feet northeast of, 15 feet northeast of road, in top of granite boulder 36 by 60 inches and 30 inches high; bronze tablet stamped "1496 G"-----	1,496.057
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SPRINGVILLE, EAST ALONG ROAD TO ELSTER'S RANCH (SINGLE SPUR LINE).

Elster's ranch house, 300 feet west of, south of Middle Fork of Tule River, south of road, 10 feet southwest of gate, granite boulder 30 by 30 inches and 14 inches high; bronze tablet stamped "1206 G"-----	1,206.284
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CITRUS SCHOOL, VIA COUNTY ROAD, TO FRAZIERS SCHOOL (SINGLE SPUR LINE).

T. 20 S., R. 28 E., sec. 32, Fraziers school, 18 inches east of, 18 inches south of steps at north entrance; iron post stamped "585 G"-----	585.419
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PORTERSVILLE, EAST ALONG COUNTY ROAD, TO WORTH SCHOOL (SINGLE SPUR LINE).

T. 22 S., R. 28 E., sec. 3, Worth school, 45 feet south of, 3 feet east of gate; iron post stamped "571 G"-----	570.515
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WET MEADOWS, SOUTHEAST ALONG LITTLE KERN RIVER, NORTH UP SHOTGUN CREEK, SOUTHEAST ALONG POISON MEADOW TRAIL, TO GREAT WESTERN DIVIDE, CONNECTING WITH WORK ON OLANCHA QUADRANGLE.

Great Western Divide, in saddle of spur running west from about 0.25 mile south of Rifle Creek, 10 feet east of Poison Meadow trail, in granite rock; aluminum tablet stamped "9046 G 1905"-----	9,046.100
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COALINGA AND HANFORD QUADRANGLES.

FRESNO AND KINGS COUNTIES.

The elevations in the following list depend upon a bench mark on the precise-level line from Benicia at a point 0.4 mile south of Goshen, opposite milepost 241, a spike in base of telegraph pole, the adjusted elevation of which is 282.661 feet above mean sea level. The line was run in both forward and backward directions and the mean taken.

The leveling was done by Mr. W. V. Hardy, levelman, in the spring of 1903.

GOSHEN TO ALCALDE.

HANFORD QUADRANGLE.

GOSHEN, WEST ALONG WAGON ROAD, TO LEMOORE; THENCE WEST ALONG SOUTHERN PACIFIC RAILROAD, TO BENCH MARK 4 MILES WEST OF LETHENT.

	Feet.
Goshen, 6.34 miles west of, 100 feet northwest of road crossing, 50 feet north of track, 2 feet east of corner of railroad fence; iron post stamped "251 G"-----	251.198
Hanford, 4.58 miles northeast of, northwest angle of road intersection; iron post stamped "255 G"-----	254.765
Hanford, King County Court-house, east side of south entrance, in granite balusters; aluminum tablet stamped "250 G"-----	250.385
Armona school, 180 feet northwest of south of gate, at northwest corner of yard; iron post stamped "237 G"-----	237.211
Lemoore, Union High School, north side of east entrance, in foundation wall, 1 foot above surface of ground; aluminum tablet stamped "223 G"-----	223.199
Lethent, 60 feet northwest of barn, south of track, 2.5 feet east of telegraph milepole 267; iron post stamped "219 G"-----	219.135
Lethent, 4 miles southwest of, 4 feet east of telegraph milepole 271, south of track; iron post stamped "250 G"-----	250.118

COALINGA QUADRANGLE.

BENCH MARK 4 MILES WEST OF LETHENT, WEST ALONG SOUTHERN PACIFIC RAILROAD, TO ALCALDE.

Huron, 4.3 miles northeast of, 50 feet south of track, 3 feet east of telegraph milepole 276; iron post stamped "306 G"-----	306.166
Huron school, 2.5 feet south of entrance; iron post stamped "380 G"-----	380.231
Arroyo Posa Jhena, 0.99 mile southwest of, 50 feet south of track, 3 feet east of telegraph milepole 285; iron post stamped "455 G"-----	455.147
Ora, 3.98 miles east of, 50 feet south of track, 8 feet north of wagon road, 5 feet east of telegraph milepole 290; iron post stamped "569 G"-----	569.216
Ora, 2.13 miles east of, 50 feet south of track, 5 feet east of telegraph milepole 292; iron post stamped "606 G"-----	606.101
Ora, 2.5 feet west of telegraph pole marked with name of station, south of oil tanks, 50 feet south of tracks, 2 feet north of wire fence; iron post stamped "647 G"-----	647.187
Coalinga, southwest end of station; iron post stamped "671 G"-----	671.152

	Feet.
Coalinga, 1.73 miles southwest of, in mouth of Waltham Canyon, 800 feet north of ranch house, 50 feet south of track, 10 feet northwest of road junction; iron post stamped "716 G"-----	716.110
Alcalde, 70 feet north of station, between station signboard posts; iron post stamped "852 G"-----	852.214

DUNLAP, FRESNO, KAISER, AND TEHIPITE QUADRANGLES.

FRESNO, MADERA, AND TULARE COUNTIES.

The elevations in the following list are based upon the precise line along the Southern Pacific Railroad. The line Fresno to Madera is adjusted, but the remainder of this list is unadjusted on account of excessive discrepancy in joining work brought from Goshen with that from Fresno. The leveling on the Tehipite quadrangle and on lines from Three Springs and from Millwood to Dunlap on Dunlap quadrangle are based upon an adjusted elevation at Kaweah Bridge on Kaweah quadrangle, in turn based upon an adjusted height at Goshen. The leveling on the Fresno and Kaiser quadrangles and west of Dunlap on Dunlap quadrangle are based upon adjusted elevation at Fresno.

On account of discrepancy the line Kaweah Bridge via Cedar Grove to Three Springs was rerun throughout and in some sections a third running was made. A comparison of these runnings over great differences of elevation enabled rod corrections to be determined, and gross errors to be eliminated. The corrected mean values are used.

The leveling on Kaiser quadrangle and on line Fresno to Kaiser quadrangle was done by Mr. L. D. Ryus in 1901, and to this no rod correction has been applied and no adjustment made except between Fresno and Clovis; the remainder of leveling on Fresno quadrangle was done in 1902-3 by Mr. Ryus.

The first running on lines Snow Corral to Cedar Grove in 1902 and Kaweah Bridge to Cedar Grove in 1903, and the work on lines to Dunlap from Three Springs, Horse Corral, and Fresno in 1903 was done by Mr. Ryus. The rerunning Three Springs via Cedar Grove to Kaweah Bridge was done by Mr. R. A. Farmer, topographer, in 1904-5.

Rod corrections have been applied to the Ryus 1902-3 lines at rate of 0.0001 foot per vertical foot, decreasing differences; and to Farmer's 1904 line 0.0003 foot, increasing differences.

The list as it stands contains the following breaks, to be corrected when further connections have been obtained: At Snow Corral—from Kaweah=7,119.44 feet; from Fresno=7,115.76 feet. At Dunlap—from Three Springs=1,915.38 feet; from Horse Corral=1,915.47 feet; from Fresno=1,911.93 feet.

TEHIPITE QUADRANGLE.

KAWEAH BRIDGE, NORTHEAST VIA MARBLE FORK AND HORSE CORRAL, TO CEDAR GROVE.

	Feet.
T. 16 S., R. 28 E., sec. 26, 7 miles north of Kaweah Bridge, on point of hill on grade 2 miles north of Davis ranch, in top of 5 by 6 foot rock on east side of road; bronze tablet.....	1, 279.07
Sequoia National Park, 2,100 feet south of Cedar Creek Camp, west side of road at point of hill, in granite ledge; bronze tablet.....	3, 789.80
Sequoia National Park, 130 feet east of Marble Fork Bridge, east of road and Marble Fork of Kaweah River on Giant Forest road, 50 feet north of small bridge over stream, in granite ledge; bronze tablet.....	5, 161.00
Sequoia National Park, at upper crossing of Marble Fork of Kaweah River, 200 feet south of Marble Fork, 25 feet west of trail, in granite rock; bronze tablet.....	6, 720.24
T. 14 S., R. 30 E., "J. O." Pass about 2 miles north of Clover Creek, 15 feet east of trail, 10 feet from signboard tree, in rock; bronze tablet.....	9, 414.97
Horse Corral Meadow, sec. 32, T. 13 S., R. 30 E., at fork of King River and Millwood and Giant Forest trails, at foot of mound, in top of granite rock; bronze tablet.....	7, 648.90

CEDAR GROVE, NORTHWEST VIA TEHIPITE, CROWN VALLEY, AND SAMPLER COW CAMP, TO SNOW CORRAL MEADOWS.

Cedar Grove Hotel, 0.25 mile east of sec. 13, T. 13 S., R. 30 E., 250 feet north of trail, 600 feet north of bridge over South Fork of King River, in granite rock, 6 feet high; bronze tablet.....	4, 635.02
Happy Gap or Red Saddle, sec. 30, T. 12 S., R. 30 E., summit of ridge between Middle Fork and South Fork of King River, in ledge of rock 40 feet south of trail; bronze tablet.....	9, 310.83
T. 12 S., R. 29 E., sec. 11, Tehipite Valley, 1.3 miles south of Tehipite Dome, 200 feet north of ford, west bank of Middle Fork of King River, in large rock; bronze tablet.....	4, 085.70
Crown Valley or Collins Meadow, sec. 30, T. 11 S., R. 29 E., at junction of Tunamah and Tehipite trails, 100 feet east of Rogers corral, at Crown Valley Camp, in granite rock, 4.5 feet high, 10 feet square; bronze tablet stamped "7879 F".....	7, 882.69
Three Springs, 1.5 miles east of, sec. 16, T. 11 S., R. 28 E., south side of trail, 200 feet west of small meadow, at rocky point 2 miles west of creek, 700 feet east of summit of ridge, in granite ledge; bronze tablet.....	8, 274.41
Cliff Camp, 1 mile northwest of, north line of, sec. 12, T. 11 S., R. 27 E., in granite ledge on west bank of North Fork of King River, 50 feet north of sheep bridge; tablet.....	6, 177.98

THREE SPRINGS, SOUTH TO RODGERS RIDGE.

T. 12 S., R. 27 E., sec. 1, 5.5 miles southwest of Three Springs, 150 feet south of forks of trail on Rodgers Ridge, about 3.5 miles south of crossing of Rancheria Creek, in rock; bronze tablet.....	6, 844.28
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PRIMARY LEVELING.

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HORSE CORRAL MEADOWS, WEST ALONG TRAIL VIA BIG MEADOW AND GENERAL GRANT PARK, TO
MILLWOOD.

	Feet.
Big Meadows, sec. 8, T. 14 S., R. 29 E., 125 feet south of road, between Ellis Camp and Open Meadow, at foot of rock mound; bronze tablet.....	7, 662.74
Log Corral Meadow, sec. 4, T. 14 S., R. 28 E., 300 feet west of forks of General Grant Park and Happy Gap trails, 50 feet south of Happy Gap and Millwood trails, north side of road, in granite rock; bronze tablet.....	7, 229.19

DUNLAP QUADRANGLE.

RODGERS RIDGE, SOUTHWEST TO DUNLAP.

Three Springs, 11.75 miles southwest of, between South and North forks of King River, at point where Rodgers trail from river reaches summit, 10 feet west of trail, in rock; bronze tablet.....	4, 672.98
King River, crossing on Rodgers trail at Flume station No. 3, 130 feet north of river, 100 feet north of trail, in rock; bronze tablet stamped "1030".....	1, 034.03
Dunlap, 7 miles north of, 4.33 miles south of King River, 2 miles north of Akers (jr.) house, in saddle of ridge, 50 feet west of trail, in granite ledge; bronze tablet.....	3, 566.23
Dunlap, 5 miles north of, summit of divide between Dunlap and White Deer Flat, southwest corner of pasture, 50 feet east of road, inside of fence; bronze tablet.....	2, 399.94
Dunlap, 25 feet east of gate to Mountain Home Hotel, flush with ground, against fence, in rock; bronze tablet.....	1, 915.38

MILLWOOD, WEST TO DUNLAP.

Millwood, opposite junction of flumes at north side of Sanger Lumber Company's shipping yard, in granite ledge in hill; bronze tablet....	5, 111.93 •
Dunlap, 2 miles east of, north side of road, at point of hill, in granite ledge 4 feet high; bronze tablet.....	2, 388.98

KINGRIVER POST-OFFICE, EAST TO DUNLAP.

Kingriver post-office, 3 miles east of, at intersection of Millwood and Sanger and Reedly roads, at southwest corner of vineyard; iron post.....	395.32
Kingriver post-office, 7 miles east of, in front of Clarks Valley church, south side of road, in top of granite ledge; aluminum tablet.....	470.28
Kingriver post-office, 10 miles east of, 3 miles east of Clarks Valley Church, 1.75 miles west of Street's eating house, 0.25 mile east of small ridge crossing road, granite rock, 4 by 8 by 114 feet, on road right of way; aluminum tablet stamped "587 F" (?).....	586.80
Squaw Valley post-office, 100 feet southeast of, in rock; aluminum tablet stamped "1692 F".....	1, 693.09
Dunlap, 5.4 miles west of, 5.33 miles east of Squaw Valley store, 2 miles west of Mr. Irvin's house, west side of tributary of Mill Creek, 5 feet north of road, in top of granite ledge; aluminum tablet stamped "1501 F".....	1, 501.84

NEAR LETCHER, NORTHEAST TO HUMPHREYS STATION.

	Feet.
Humphreys, 700 yards north of station, 6 feet west of road, 100 feet west of creek, at small flat, in granite ledge; aluminum tablet stamped "1048 F"-----	1, 044. 424

FRESNO QUADRANGLE.

FRESNO, EAST ALONG STAGE ROAD TO KINGRIVER POST-OFFICE.

Fresno, Southern Pacific Railroad passenger station; tablet-----	289. 983
Fresno, 3 miles east of station, 400 feet west of crossing of Sunnyside car line and Ventura avenue, 1 mile east of Fresno schoolhouse, south edge of road; iron post-----	304. 849
Fresno, 6 miles east of, northeast corner of Sunnyside vineyard, north side of Centerville road, west side of Fowler road, at intersection; iron post stamped "323 B"-----	323. 024
Fresno, 9 miles east of, on south edge of Centerville road, 40 feet east of section line, opposite square yellow house; iron post-----	348. 49
Centerville, 4 miles west of, 50 feet west of corner of section, at road crossing, between wheat ranches, south edge of road; iron post-----	372. 77
Centerville (Kingsriver post-office), 1 mile west of, 0.25 mile east of Fowler ditch, south edge of county road; iron post-----	393. 35

FRESNO, ALONG SOUTHERN PACIFIC RAILROAD RUNNING EAST, TO LAS PALMAS (MALTER-MORO); THENCE NORTH VIA CLOVIS, TO POLLASKY; THENCE ALONG HIGHWAY WEST, TO CLOSURE ON PRECISE LINE AT MADERA.

Barton, 1.2 miles east of, in southeast corner of vineyard, north of schoolhouse, east of wagon road, south of track; iron post-----	316. 556
Tarpy, 150 feet north of station platform, at southwest corner of northwest quarter sec. 20, T. 13 S., R. 21 E., on ditch bank west of track; iron post-----	347. 187
Clovis, at west edge of railroad right of way, 75 feet south of first switch block south of planing mill; iron post-----	356. 084
Gordon, 150 feet north of south end of switch, at west edge of railroad right of way; iron post stamped "391"-----	391. 250
Pollasky, 450 feet south of station, opposite milepost 231, at east edge of right of way of railroad; iron post stamped "337"-----	337. 035
Pollasky, 6.25 miles west of, 75 feet north of corner of small pasture at rocky point, south side of road; iron post stamped "451"-----	451. 155
Cottonwood schoolhouse, 0.5 mile north of, north side of road, against fence of adobe ranch; iron post stamped "342"-----	342. 188
Madera, 4 miles east of, 200 feet east of first small hill south of Sugar Pine and Madera road, 20 feet south of lumber flume, at north side of public road; iron post stamped "304"-----	304. 347

CLOVIS, NORTHEAST ALONG ROAD, TO NEAR LETCHER.

Flume section house No. 7, 50 feet north of, 3 miles northeast of Clovis, east side of road; iron post-----	409. 100
Collins ranch, 1.1 miles east of, southwest of section house No. 6, south side of road, opposite curve in flume; iron post-----	460. 849
Letcher, 0.5 mile north of, in granite rock in pasture, 50 feet east of county road; aluminum tablet stamped "601 F"-----	597. 241

KAISER QUADRANGLE.

HUMPHREYS STATION, NORTH ALONG ROAD VIA TOLLHOUSE AND OCKENDEN, TO SHAVER.

	Feet.
Pine Ridge, sec. 9, T. 10 S., R. 24 E., 100 feet south of store and post-office, in top of granite bowlder 5.5 by 8 feet; aluminum tablet stamped "4942 F"-----	4, 938. 332
Shaver, sec. 13, T. 9 S., R. 24 E., 150 feet north of mill and machine shop, in granite ledge; aluminum tablet stamped "5275 F" (on a single spur line)-----	5, 271. 531

MUSIC'S OLD MILL (OCKENDEN), OVER COUNTRY ROAD AND TRAIL VIA MARKWOOD AND DINKEY CREEK MEADOWS, TO DIVIDE BETWEEN BEAR AND DEER CREEKS ON KINGS RIVER TRAIL.

T. 10 S., R. 25 E., sec. 12, 2.5 miles east of Markwood Meadows, 400 feet south of road, east of Summit Meadows, in granite ledge; aluminum tablet stamped "6492 F"-----	6, 488. 598
Dinke Meadows, sec. 20, T. 10 S., R. 26 E., 50 feet south of road, 300 feet south of first cabin, about 0.5 mile west of bridge over Dinkey Creek and 300 feet south of south bank, in granite rock; aluminum tablet-----	5, 607. 484
Snow Corral, 4.5 miles east of Bear Creek, at point of hill, 50 feet north of trail, on east slope of hill west of meadow, 0.8 mile east of summit of ridge, in granite rock; aluminum tablet stamped "7118 F" (elevation by Tehipite levels from Kaweah 7,119.44)-----	7, 115. 758

DINKEYS MEADOWS, NORTH VIA TRAIL, TO MOUTH OF TAMARACK CREEK.

T. 9 S., R. 26 E., sec. 30, 1.7 miles north of Dry Meadows, east of trail, at summit of ridge, in granite ledge at curve; aluminum tablet stamped "7202 F"-----	7, 199. 924
T. 8 S., R. 25 E., sec. 35, Tamarack Creek, 150 feet from ford, west of Red Mountain trail, in granite bowlder; aluminum tablet stamped "7141 F"-----	7, 148. 935

MOUTH OF TAMARACK CREEK, VIA MONO TRAIL AND MONO CREEK CROSSING, TO 2.3 MILES NORTHEAST OF SOUTH FORK OF SAN JOAQUIN RIVER.

T. 8 S., R. 26 E., sec. 18, Big Creek, 0.6 mile north of crossing, east of north fork of Big Creek, 200 feet east of ford, in granite ledge; aluminum tablet stamped "6876 F"-----	6, 883. 669
T. 7 S., R. 26 E., sec. 26, Kaiser Ridge, summit of divide north of Kaiser Pass, east of trail, opposite Luck Point, in granite bowlder; aluminum tablet stamped "9295 F"-----	9, 302. 591
T. 7 S., R. 27 E., sec. 7, 100 feet north of South Fork of San Joaquin River, 200 feet west of Mono trail ford, in granite ledge at foot of bluff; aluminum tablet stamped "6405 F"-----	6, 412. 356

MONO CREEK, ON MONO TRAIL, NORTHWEST VIA CATTLE TRAIL, TO MILLER'S BRIDGE, OVER MIDDLE FORK OF SAN JOAQUIN RIVER.*

T. 6 S., R. 26 E. (unsurveyed), 3.2 miles southeast of Rock Creek, in flat small meadow, 10 feet south of trail, in granite bowlder; bronze tablet stamped "7061 F"-----	7, 068. 706
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* See under "Mount Lyell quadrangle," p. 118.

	Feet.
Bear Meadow, 0.5 mile northwest of, south of trail, on summit west of Bear Meadow, in granite ledge; bronze tablet stamped "7554 F"-----	7,561.709
Cassidy Meadow, south side of Rattlesnake Lake, sec. 24, T. 5 S., R. 25 E., east of granite point, in ledge between trail and lake; bronze tablet stamped "5576 F"-----	5,583.419

TOLLHOUSE SCHOOLHOUSE, NORTHWEST ALONG PUBLIC ROAD, TO POWER HOUSE; THENCE ALONG PIPE LINE, TO RESERVOIR; THENCE ALONG DITCH TO A POINT 2 MILES SOUTHEAST OF NORTH FORK.

T. 10 S., R. 23 E., sec. 8, south of intersection of Pine Ridge and power-house roads, in top of granite ledge; bronze tablet stamped "2013 F"-----	2,009.411
T. 9 S., R. 23 E., sec. 18, San Joaquin, light and power house, at northeast corner of building, in granite pillar; bronze tablet stamped "1013 F"-----	1,009.326
T. 8 S., R. 23 E., sec. 30, North Fork, 2 miles southeast of post-office, west of road and ditch, at sharp curve above field and house, in granite boulder 10 by 8 feet; bronze tablet stamped "2503 F"-----	2,499.788

LOS BANOS, MERCED, SONORA, AND YOSEMITE QUADRANGLES.

MARIPOSA AND MERCED COUNTIES.

The elevations in this list are based on an aluminum tablet in southeast corner of the county court-house at Merced. The elevation of this is accepted as 171.118 feet above mean sea level as determined by precise leveling from Benicia.

The work was done in 1905 mostly by Mr. C. H. Semper, levelman, partly run as a double-rodged line and partly the mean of lines run in opposite directions. The connection Yosemite Point to Snow Flats was made by Mr. R. A. Farmer, topographer.

MERCED QUADRANGLE.

MERCED, ALONG HIGHWAY, TO MERCED RIVER.

	Feet.
Merced, southeast corner of county court-house; aluminum tablet stamped "171 B"-----	171.118
Merced, 4.3 miles north of, at entrance to Crocker Huffman back ranch, west side of road, 20 feet north of gate; iron post stamped "175 B"-----	175.222
Sixmile House, northeast corner of fork with road to east; iron post stamped "206 B"-----	205.775
Sixmile House, 3.3 miles north of, 65 feet south of bridge over creek, east side of road; iron post stamped "377 B"-----	376.949
Sixmile House, 6.7 miles north of, at northwest corner of fork with road to west; iron post stamped "284 B"-----	283.913

AMSTERDAM, SOUTHEAST ALONG RAILROAD, TO MERCED.

Amsterdam, 3.3 miles southeast of, north margin of railroad and highway, 4 feet east of milepost 157; iron post stamped "196 B"-----	195.984
Amsterdam, 6.4 miles southeast of, at southwest corner of fork with road to Atwater, at J. J. Gray's ranch house; iron post stamped "175 B"-----	175.333

PRIMARY LEVELING.

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LOS BANOS QUADRANGLE.

SNELLING, WEST TO HOPETON; THENCE SOUTH TO AMSTERDAM.

	Feet.
Snelling, 4.5 miles southwest of, at corner of fork with road to north, at fence corner of J. G. Ruddle's ranch; iron post stamped "204 B"-----	204. 037
Hopeton, at southeast corner of fork with private road, in front of saloon; iron post stamped "185 B"-----	184. 986
Hopeton, 2.2 miles south of, southwest end of bridge over Merced River, west margin of road; iron post stamped "172 B"-----	172. 245
Amsterdam, 140 feet west of large warehouse, 10 feet east of station signboard, 20 feet north of track; iron post stamped "215 B"-----	215. 156

SONORA QUADRANGLE.^a

MERCED RIVER, NORTHEAST TO SNELLING; THENCE EAST TO MERCED FALLS; THENCE NORTH-EAST TO COULTERVILLE; THENCE EAST TO 2.4 MILES SOUTHEAST OF BOWER CAVE.

Snelling, 1.7 miles southwest of, 640 feet north of Merced River roller mills, 60 feet southeast of end of bridge over Merced River, at fence line; iron post stamped "243 B"-----	243. 114
Snelling, at southwest corner of Lewis and Third streets; iron post stamped "259 B"-----	259. 008
Snelling, 2.7 miles east of, on south side of road, on line of east margin of I. J. Buckley's brick ranch house; iron post stamped "291 B"-----	291. 026
Merced Falls, at northeast corner of yard of Merced Falls Power Company, on margin of road; iron post stamped "351 B"-----	351. 125
Merced Falls, 2.9 miles north of, at summit of mountains, 30 feet west of road; iron post stamped "764 B"-----	763. 825
Webbs, at southwest corner of yard fence, margin of road; iron post stamped "1046 B"-----	1, 045. 953
Peter Senges, at gate leading to ranch house, at margin of fence; iron post stamped "1128 B"-----	1, 127. 958
Peter Senges, 1.5 miles north of, at junction of Piney Creek with Merced River, 125 feet south of creek, 700 feet west of river, near corner of fence; iron post stamped "556 B"-----	555. 979
Baxter post-office, northeast corner of yard fence; iron post stamped "1250 B"-----	1, 249. 912
Baxter, 3.1 miles north of, at junction of roads to Coulterville and Horseshoe Bend, 10 feet south of stage station office; iron post stamped "858 B"-----	857. 965
Coulterville, opposite southeast corner of Jeffrey's Hotel, at corner of street in front of burned brick building; iron post stamped "1676 B"-----	1, 676. 092
Coulterville, 2.5 miles east of, 0.6 mile east of forks of road, at horse-shoe bend in road, south side of fence line, near large oak 4 feet in diameter; iron post stamped "2211 B"-----	2, 211. 034
Coulterville, 5.7 miles east of, at summit of mountain, 0.4 mile east of Mountain View saloon, 15 feet south of road; iron post stamped "3346 B"-----	3, 346. 039
Bean Creek Bridge, 1.5 miles east of, in front of W. H. Dudley's ranch house, at northwest corner of front yard fence; iron post stamped "2984 B"-----	2, 984. 063

^a For additional elevations outside this quadrangle see p. 121.

	Feet.
Bower Cave, at road crossing North Fork of Merced River, 50 feet east of river, at north margin of road; iron post stamped "2349 B"-----	2, 349.038
Bower Cave, 2.4 miles southeast of, at northeast corner of school-house yard; iron post stamped "2939 B"-----	2, 939.069

YOSEMITE QUADRANGLE.

NEAR BOWER CAVE, SOUTHEAST TO MERCED RIVER; THENCE EASTERLY ALONG SAME TO YOSEMITE VALLEY.

Kinsley, on south side of road, at margin of fence, directly opposite post-office; iron post stamped "2715 B"-----	2, 714.998
Jenkins Mountain, summit of mountain, on trail, 15 feet south of large oak; iron post stamped "3289 B"-----	3, 289.039
Jenkins Mountain, at east foot of, 145 feet west of Big Grizzly Creek, 130 feet north of Merced River, 30 feet east of old cabin, at edge of trail; aluminum tablet ^a stamped "1324 B"-----	1, 323.761
Ned Gulch, 1.9 miles east of, 0.5 mile east of junction of South Fork with river, on long flat ground, at foot of slope, north side of large rock; aluminum tablet stamped "1425 B"-----	1, 424.982
Furgeson Mine, 2.2 miles east of, 2 feet south of bridge over Merced River, west abutment, 20 feet east of west end; aluminum tablet stamped "1586 B"-----	1, 585.008
Merced River Bridge, 2.5 miles east of, at west foot of steep grade, in open ground covered with boulders, 35 feet east of trail, large granite rock, in river face; aluminum tablet stamped "1824 B"-----	1, 823.966
Crane Creek, 0.8 mile east of, trail nearly level with river, 95 feet west of common corner of secs. 9, 10, 15, and 16, T. 3 S., R. 20 E., 10 feet east of large crooked oak, perpendicular rock; aluminum tablet stamped "2117 B"-----	2, 116.969
Crane Creek, 2.4 miles east of, 260 feet north of zig zag in trail close to river; in face of perpendicular rock; aluminum tablet stamped "2738 B"-----	2, 738.001
Cascade House, 0.7 mile south of, on main road, 100 feet southwest of junction of road with river trail, in face of perpendicular rock; aluminum tablet stamped "3511 B"-----	3, 510.981
Yosemite, 50 feet west of west boundary stake of old State park, on north side of road to Cascade Falls, large granite boulder; aluminum tablet stamped "3576 B"-----	3, 576.004
Yosemite Valley, north side of river, at west turn to bridge near margin of road, 75 feet northwest of Pohone Bridge, large boulder; aluminum tablet stamped "3880 B"-----	3, 879.767
Yosemite Valley, directly opposite Guardian's office, at east margin of road, top of large granite rock; aluminum tablet stamped "3964 B"-----	3, 964.287
Yosemite Valley, at junction of roads, north side of river, north and east side of roads, 150 feet northeast of iron bridge over Merced River, at Sentinel Hotel, in center of top of concrete pier 2.5 feet high, base 20 by 20 inches, and top 12 by 12 inches; aluminum plug stamped with a triangle, and "U. S. G. S."-----	3, 960.006

^a From this point the old system of double rod was used.

	Feet.
Immediately over above bench mark is a rectangular aluminum plate half inch thick marked "Charles D. Walcott, Director, U. S. Geological Survey, Latitude 37° 44' 40'', Longitude 119° 35' 21''--	3, 960. 138
Yosemite Valley, at power house, 40 feet south of trail to Vernal Falls, 40 feet north of power house bridge, 30 feet north of road, large granite boulder; aluminum tablet stamped "4034 B"-----	4, 034. 061

UP YOSEMITE FALLS TRAIL, NORTHEAST TO SNOW FLAT.

Yosemite Valley, at foot of trail to Yosemite Falls, 100 feet west of road, 30 feet south of trail, face of large granite boulder; aluminum tablet stamped "3989 B"-----	3, 989. 013
Yosemite Valley, south of trail to Yosemite Falls, in rock; aluminum tablet stamped "F 1905 5031"-----	5, 030. 576
Yosemite Valley, in angle of trail to Yosemite Falls, 100 feet from large flat rock used as lookout to bottom of falls, top of large granite rock; aluminum tablet stamped "5143 B"-----	5, 142. 666
Yosemite Valley, top of Yosemite Falls, east side of bridge over Yosemite Creek, south side of rock foundation of abutment; aluminum tablet stamped "6603 B"-----	6, 603. 056
Yosemite Point, at west end of iron railing; triangulation tablet----	6, 934. 616
Summit north of trail, rock 5 feet base, 3 feet high; aluminum tablet stamped "F 7852 1905"-----	7, 851. 765
Junction of trail with Tioga wagon road, south of, on rock 3 by 3 by 3 feet; aluminum tablet stamped "7981 F"-----	7, 981. 013

BRIDGEPORT AND MOUNT LYELL QUADRANGLES.

MONO AND TUOLUMNE COUNTIES.

The elevations in the following list are determined mostly by single unadjusted lines based upon a new elevation at Snow Flats which was determined in 1905 by a single spur from a double-run spur line run to Yosemite Valley from a bench mark at Merced on the precise-level line from Benicia.

The results were formerly published in the Appendix to the Twentieth Annual Report, based upon a double-rodged line from Stockton; but as now corrected the elevations by this list are 4.389 feet greater than by the corrected line from Stockton and 6.355 lower than by single line of 1905 from Laws. Part of a circuit to Mono Mills is on Benton quadrangle (p. 101).

The leveling was done in 1898 under Mr. R. B. Marshall, topographer, by Mr. C. R. Smith, levelman. The bench mark at Miller Bridge was established by L. D. Ryus, levelman, in 1901, from Fresno.

BRIDGEPORT QUADRANGLE.

TO HARDY STATION FROM BENCH MARK 2.5 MILES WEST.

	Feet.
Hardy station, about 2.5 miles west of, on rock ledge 1,400 feet east of bridge over West Walker River, in a bend of the road, on south side of grade; copper bolt stamped "6703" (elevation by corrected line from Stockton, 6,702.518)-----	6, 706. 907

	Feet.
Hardy station, at junction of Sonora-Mono toll road and the Carson road, 60 feet east of Little Walker River; iron post stamped "6942"-----	6, 945.830
HARDY STATION, SOUTH ALONG MAIN ROAD, TO BRIDGEPORT; THENCE SOUTHEAST TO BOWIE; THENCE SOUTHWEST TO MONO LAKE.	
Summit between Hardy and Bridgeport, 15 feet east of road; iron post stamped "7540 O"-----	7, 544.812
Hunttoon station, on right side of road, 100 feet below water trough; iron post stamped "6837 O"-----	6, 841.999
Bridgeport, 3 miles northwest of, east side of road, at north side of Simmon's Lane; iron post stamped "6496 O"-----	6, 500.556
Bridgeport, at southwest angle of court-house; iron post stamped "6465 O"-----	6, 469.436
Tollgate, Bridgeport, and Bodie road, near northeast corner of gate; iron post stamped "6643 O"-----	6, 647.946
Clearwater Creek crossing, 20 feet north of bridge; iron post stamped "7196 O"-----	7, 201.323
Sheep camp, across road from water trough and 50 feet above; iron post stamped "7350 O"-----	7, 354.824
Hectors station, on Bodie and Lundy road, across road from the dwelling house at edge of orchard and garden; iron post stamped "6760 O"-----	6, 765.322
Jordan Creek crossing of Bodie and Lundy road, 150 feet south of bridge, on north side of road; iron post stamped "6779 O"-----	6, 783.407
T. 2 N., R. 26 E., Diablo meridian, 4 feet east of southwest corner of sec. 19, witnessed by mound of rocks, about midway between Mono post-office and Mono schoolhouse, on hillside, about 350 feet in elevation above lake and about 2,000 feet in horizontal distance from lake shore; iron post stamped "6761 O"-----	6, 765.714
Mono Lake; surface of water, July 27, 1898-----	6, 417.3

MOUNT LYELL QUADRANGLE.

MONO LAKE POST-OFFICE, SOUTHEAST TO RUSH CREEK.

Ney's ranch, sec. 4, T. 1 N., R. 26 E., near Mono Lake shore, in large bowlder on north side of road and 200 feet east of blacksmith shop; aluminum tablet stamped "6423 O"-----	6, 427.471
T. 1 N., R. 26 E., sec. 13, Rush Creek crossing, junction of lake road with Rush Creek road from Farrington station; iron post stamped "6442 O"-----	6, 446.571
NEY'S RANCH (SHORE OF LAKE MONO), SOUTH ALONG ROAD, TO JUNCTION OF ROAD IN SEC. 9, T. 2 S., R. 27 E.	
T. 1 N., R. 26 E., northeast corner, sec. 33, Farrington station, 50 feet south of dwelling, inside of fence at edge of road to Walter Lake; iron post stamped "6854 O"-----	6, 858.729
T. 1 S., R. 27 E., sec. 29, Owens River road, 7 miles southeast of Farrington station, at head of short, steep grade, at upper edge of grove of trees, 10 feet left of road; iron post stamped "7601 O" (elevation brought from Mohave, 7,612.182)-----	7, 605.827
T. 2 S., R. 27 E., sec. 9, Long Valley and Owens River road, at junction of with Bodie and Benton wagon road, on north side of road; iron post stamped "7938 O" (elevation brought from Mohave, 7,948.998)-----	7, 942.643

FARRINGTON, SOUTH TO SILVER LAKE.

	Feet.
Grant Lake, at outlet of, 10 feet east of road; iron post stamped "7068 O"-----	7, 073. 228
Silver Lake, at outlet of; iron post stamped "7217 O"-----	7, 221. 937

NEY'S RANCH, UP LEEVINING CREEK ROAD, TO SEC. 23, T. 1 N., R. 26 E.

T. 1 N., R. 26 E., quarter corner between secs. 23 and 24; iron post stamped "7467 O"-----	7, 472. 097
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FARRINGTON STATION, SOUTHWEST ALONG ROAD AND TRAIL, TO MONO PASS; THENCE WEST ALONG TRAIL, TO SNOW FLAT.

Walker Lake, 100 feet north of outlet of, at upper end of wagon road where Bloody Canyon trail begins, near dwelling of A. Grose, 100 feet from lake and 123 feet from fence; iron post stamped "7929 O"-----	7, 934. 030
Walker Lake; surface of water, September 1, 1898-----	7, 931. 6
Sardine Lake; surface of water, September 26, 1898-----	9, 881. 1
Mono Pass, 30 feet north from Shore of Summit Lake and 4 feet to right of trail; iron post stamped "10599 O"-----	10, 603. 604
Dana Fork, trail at point where sheep trail branches to right through timber alongside hill and where stream turns westward to main trail, continuing northwest down to meadows, in rock at southwest corner of cabin; aluminum plug stamped "U. S. G. S. 9738 Ft. B. M. O."-----	9, 742. 563
Soda Springs, 3.5 miles east of, on north side of Tioga road where trail comes in from the meadows to the eastward of road, in out-cropping ledge of rock; aluminum bolt stamped "U. S. G. S. 9270 Ft. B. M. O."-----	9, 274. 794
Soda Springs, 100 feet west of, in large granite boulder on south side of trail; aluminum bolt stamped "U. S. G. S. 8594 Ft. B. M. O."-----	8, 598. 681
T. 1 S., R. 23 E., southeast corner sec. 1, Diablo meridian; iron post stamped "8555 O"-----	8, 560. 118
Cathedral Creek, in conspicuous rock in north side of creek bed, 50 feet from road; aluminum bolt stamped "U. S. G. S. 8337 Ft. B. M. O."-----	8, 342. 076
Lake Tanaya, on west shore of, in large boulder between road and lake shore, about 300 feet east of three log cabins in grove of trees; aluminum tablet stamped "U. S. G. S. 8146 Ft. B. M. O."-----	8, 150. 447
Lake Tanaya; surface of water, September 17, 1898-----	8, 146.
Snow Flat, 300 feet southwest of wooden culvert in road crossing, in large granite boulder, on west side of road; aluminum tablet stamped "U. S. G. S. 8705 Ft. B. M. O." (recovered in 1905 by leveling from Merced, and correction made)-----	8, 710. 341

DANA FORK, TRAIL NORTH TO TIOGA.

Tioga Pass summit, on rock on east side of road; aluminum tablet stamped "9941 Ft. B. M. O."-----	9, 946. 188
Tioga mine, in ledge of rock, at southwest corner of assay office; round iron plug set in cement and marked "9795"-----	9, 799. 745

AT MILLER BRIDGE.^a

Miller Bridge, sec. 11, T. 5 S., R. 25 E., 15 feet east of bridge over Middle Fork of San Joaquin River, in granite ledge; bronze tablet stamped "4556 F"-----	4, 563. 252
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^a Determined by single unadjusted line by L. D. Ryus in 1901 from Fresno.

BIG TREES, DARDANELLES, JACKSON, OAKDALE, SONORA, AND STOCKTON QUADRANGLES.

CALAVERAS, MONO, SAN JOAQUIN, STANISLAUS, AND TUOLUMNE COUNTIES.

The elevations in the following list are the unadjusted results of a double-rodged primary-level line previously reported upon in Appendix to the Eighteenth Annual Report, corrected in agreement with the elevation at Stockton determined by precise leveling from Benicia, being 0.492 foot greater than values previously published.

The leveling was done in 1896 by Mr. J. B. Lippincott, levelman.

This line closes 4.389 feet low upon the elevation at Hardy station, on Bridgeport quadrangle corrected in agreement with 1905 leveling from Merced.

STOCKTON QUADRANGLE.

AT STOCKTON.

	Feet.
Stockton, southwest corner of Scott avenue (south side of Mormon channel) and Center street, on north iron doorsill, west end of Cool Corner saloon; "Cool Corner" bench mark-----	15.633
Stockton, southwest corner of Scott avenue and Center street, 18 feet from curb corner and 12 feet north of iron doorsill; iron post stamped "16"-----	15.973
Stockton channel, at southeast head of, corner of Weber avenue and Eldorado street, east of steps at corner post; iron plate-----	12.714
Stockton, on the top of a stone post on the north side of the courthouse and west side of walk-----	16.1
Stockton, San Joaquin court-house, in angle of wall at north entrance, west of the door and near columns, between north door and first window west of it; bronze tablet stamped "18"-----	17.953
Stockton, Southern Pacific passenger station, Milton and Oakland branch; top of rail-----	18.7
STOCKTON, NORTHEAST ALONG MILTON ROAD AND SOUTHERN PACIFIC RAILROAD, TO PETERS.	
J. B. Marsh's house, at northeast corner of entrance of lean-to; iron post stamped "34"-----	33.605
Farmington, junction with road to, near Smyth's ranch; iron post stamped "67"-----	66.551
Peters-Linden road, at southeast corner of junction with; iron post stamped "102"-----	101.825

JACKSON QUADRANGLE.

PETERS, NORTHEAST ALONG SOUTHERN PACIFIC RAILROAD, TO MILTON.

Waverly, at crossing of the Stockton-Milton road over Southern Pacific tracks, on south side of track and east side of the crossing sign; iron post stamped "219"-----	218.285
Waverly, in front of station; top of rail-----	215.2
Milton, 9 feet north of southeast corner of Peterson & Drake's warehouse and 57 feet south of the railroad track, 60 feet west of the Southern Pacific passenger station; iron post stamped "383"-----	382.330

MILTON, EAST TO SALT SPRINGS RESERVOIR.

Salt Springs Reservoir, south side of, in large rock about 600 feet south of and in line with dam; copper bolt stamped "1092"-----	1,091.510
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PRIMARY LEVELING.

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OAKDALE QUADRANGLE.

SALT SPRINGS, SOUTHEAST VIA COPPEROPOLIS, TO MOUNT DIABLO BASE LINE.

	Feet.
Copperopolis, about 2.5 miles north of, east side of road, at a summit between Salt Spring Valley and Copperopolis, at an oblique corner of fence; iron post stamped "1108"-----	1, 107. 371
Copperopolis, in front brick wall of Fontana's store, approximately 2 feet above the store floor and 3 feet above stone foundation, opposite Vendome Hotel; bronze tablet stamped "971"-----	970. 759
O'Byrnes Ferry, Stanislaus River, in the stone front wall of Pardee's store, between south window and southeast corner of store, 500 feet north of bridge on west side of Milton-Jamestown road; bronze tablet stamped "432"-----	431. 758
O'Byrnes Ferry, 3 miles east of, at the top of and on the north side of grade, about 3 miles west of the Goodwin ranch; iron post stamped "1090"-----	1, 089. 981

SONORA QUADRANGLE.^a

MOUNT DIABLO BASE, NORTHEAST VIA SONORA, TO NEAR SOULSBYVILLE.

Goodwin's ranch, 1 mile east of house, on north side of road and 6 miles west of Jamestown; iron post stamped "1389"-----	1, 389. 045
Goodwin's wine cellar, on north step of, about 6 miles west of Jamestown and 3.5 miles north of Chinese camp; copper plug stamped "1176"-----	1, 175. 791
Jamestown, in front wall in the east end of the brick building with iron doors and a stone pavement, on the south side of the road, one-half block west of Sisson's Hotel; bronze tablet stamped "1403"-----	1, 402. 424
Sonora, in south post of east entrance in street wall of the courthouse; bronze tablet stamped "1825"-----	1, 824. 375
Sonora, in the outside wall 1 foot south of gate at the east edge of the court of Victoria Hotel, facing Washington street; copper bolt stamped "1794"-----	1, 793. 648
Soulsbyville, junction with road to, about 3 miles east of Sonora on the north side of Soulsbyville road, near the fence at the Cherokee ranch; iron post stamped "2144"-----	2, 143. 381

BIG TREES QUADRANGLE.

NEAR SOULSBYVILLE, NORTHEAST ALONG ROAD, TO PARSONS; THENCE NORTHEAST 2.5 MILES.

Columbia road, in triangle formed by junction with; iron post stamped "3254"-----	3, 253. 352
Sugarpine, about 800 feet east of post-office, on rock 12 by 6 feet, 4 feet high, in corral; copper bolt stamped "4468"-----	4, 467. 747
Sugarpine, about 2.5 miles east of, in forks of road to Hale's sawmill; iron post stamped "4916"-----	4, 916. 099
Genesee place (Saints' Rest), in rock 3.5 by 2.5 feet, 1.5 feet high, 10 feet east of barn, 10 feet south of road, 150 feet north of creek and on west edge of a group of trees; copper bolt stamped "5139"-----	5, 138. 461
Ball Mountain summit, between North Fork of Tuolumne and South Fork of Stanislaus rivers, on north side of road, about 6 miles west of Strawberry, at the northeast head of draw, on large boulder; bronze tablet stamped "5624"-----	5, 623. 563

^a For additional elevations on this quadrangle see p. 115.

	Feet.
Cold Spring, about 0.75 mile west of, at the summit between North Fork of the Tuolumne and South Fork of Stanislaus rivers, at bend of road; iron post stamped "5697"-----	5, 696.568
Parsons (Strawberry), 48.8 feet southeast from southeast corner of Parson's store and 24.8 feet from southwest corner of Parson's house, on east side of road on north side of South Fork of Stanislaus River; iron post stamped "5240"-----	5, 239.435
Strawberry, about 2.5 miles east of, in top of granite boulder at the summit between South Fork and Main Fork of Stanislaus River, and 50 feet east of road, trees blazed in vicinity; copper bolt stamped "6134"-----	6, 133.894

DARDANELLES QUADRANGLE.

POINT 2.5 MILES NORTHEAST OF PARSONS, NORTHEAST TO EUREKA VALLEY.

Cow Creek, 50 feet east of crossing of, in side of large boulder on south of road; bronze tablet stamped "5769"-----	5, 769.121
T. 5 N., R. 18 E., 2 feet north of southeast corner sec. 15, north of road between mileposts 30 and 31, 6 feet from sugar pine tree marked "B. T. 60° E. 5 feet"; iron post stamped "5943"-----	5, 942.822
Mill Creek, 200 feet east of crossing, on north side of road, trees blazed in vicinity; iron post stamped "6273"-----	6, 272.380
Niagara Creek, 150 feet north of crossing, in large granite boulder, the highest one of the group, trees blazed in vicinity; copper bolt stamped "6530"-----	6, 529.408
T. 6 N., R. 19 E., sec. 31, summit between Niagara Creek and Stanislaus River, at the head of grade and about 2,000 feet north of the Niagara Creek crossing, in a granite rock on north side of road, 4 feet above road level, on southwest face of rock; bronze tablet stamped "6638"-----	6, 637.268
T. 6 N., R. 19 E., sec. 23, about 2 miles southwest from Brightmans Flat, on south side of road, in pyramid-shaped rock 6 feet high, at level road below Pattersons grade; bronze tablet stamped "5664"-----	5, 664.204
Stanislaus River, in granite ledge 28 feet northwest from the northwest corner of bridge, and approximately 2 miles west from Douglas ranch and 6 feet above road level; copper plug stamped "5828"-----	5, 827.953
Eureka Valley, 6 feet south of southwest corner of Douglas ranch; iron post stamped "6076"-----	6, 075.838

EUREKA VALLEY, EAST VIA SONORA PASS, TO NEAR HARDY STATION.

Bakers station, about 0.25 mile southeast of, on rock bench at the foot of and west side of grade, 180 feet east of road and 93 feet south of blazed yellow pine; bronze tablet stamped "6265"-----	6, 265.105
Sonora Pass, 3 miles west of, on a rock ledge on west of road and 1,000 feet west of second crossing of the creek, trees blazed in vicinity; copper bolt stamped "8398"-----	8, 398.147
Sonora Pass, at summit of, on south side of road; iron post stamped "9623"-----	9, 623.427
Sonora Pass, 3.5 miles east of summit of, at mule corral, just west of a large canyon on south, and south of road; iron post stamped "8583"-----	8, 583.206
Crinoline grade, foot of, on top of boulder 9 feet high and 10 feet in diameter, on south side of road, 10 miles west of Hardy station and 1,360 feet west of Leavitt's chimney, between the road and fence; copper bolt stamped "7152"-----	7, 151.467

BYRON, CONCORD, MOUNT DIABLO, NEW ALMADEN, PALO ALTO, PLEASANTON, SAN FRANCISCO, SAN JOSE, SANTA CRUZ, STOCKTON, AND TESLA QUADRANGLES.

ALAMEDA, CONTRA COSTA, SAN JOAQUIN, SAN MATEO, SANTA CLARA, AND SANTA CRUZ COUNTIES.

The elevations in the following list are based upon mean sea level computed from tidal records at Martinez, Pacheco, Black Diamond, and Redwood, and further controlled at Lathrop by precise leveling from Benicia.

The leveling on San Francisco, Concord, Mount Diablo, Byron, and part of Pleasanton quadrangles was done in 1896 under Mr. L. C. Fletcher by Mr. J. A. Vogleson, levelman. Most of the work on Pleasanton and some on Stockton, Tesla, and San Jose quadrangles was done in 1903 by Mr. S. E. Blout, levelman. Most of the work on Tesla and part on Stockton quadrangles was done in 1905 under Mr. R. B. Marshall by Mr. C. H. Semper, levelman, and the work on Santa Cruz, Palo Alto, and part of San Jose quadrangles was done in 1899 under Messrs. E. C. Barnard and A. B. Searle, topographers, by Mr. C. C. Ward, levelman.

SAN FRANCISCO QUADRANGLE.

OAKLAND POINT TO OAKLAND, THENCE NORTH ALONG SOUTHERN PACIFIC RAILROAD TO SOBRANTE.

	Feet.
Oakland Point, 30.5 feet from corner of machine shop, 19 feet from corner of office of Southern Pacific Company, 1 foot from west edge of walk from railroad track to machine shops and 9 feet south from west side of doorway, 0.4 foot underground; Southern Pacific Company's bench mark on top of a 30-foot bar of railroad iron driven in solid ground by means of a pile driver (afterwards covered by a wooden platform with a hole bored through the planking so as to make it easy of access)-----	8. 151
Oakland, Broadway front of Hall of Records, in foundation on north side of entrance, 4 feet above ground; bronze tablet stamped "24"-----	24. 343

CONCORD QUADRANGLE.

MARTINEZ, SOUTHEAST ALONG HIGHWAY, NEAR PACHECO, TO CONCORD.

Pacheco, brick building, formerly a warehouse with iron shutters, owned by G. Anderson, third building north of road to Concord and post-office; iron piece projecting from wall, U. S. C. & G. S. B. M.-----	21. 210
Pacheco, 0.75 foot south of preceding bench mark, in wall of same building; bronze tablet stamped "21"-----	21. 197
Concord railroad station; top of rail at road crossing-----	42. 0
Concord, west corner of public square, southeast intersection of Main street with street running by Kline's Hotel; iron post stamped "65"-----	64. 610

DANVILLE, NORTH ALONG ROAD, TO PACHECO.

Alamo, east side of Main street, north side of lane to railroad ranch, opposite hotel and post-office; iron post stamped "270"-----	270. 327
Walnut Creek, in schoolhouse yard, between eucalyptus trees, near east fence; iron post stamped "151"-----	150. 750

MOUNT DIABLO QUADRANGLE.

ANTIOCH, SOUTHEAST ALONG SOUTHERN PACIFIC RAILROAD, TO NEROLY SIDING.

	Feet.
Neroly siding, county road just north of, gate to private road crossing, first panel east of gate; iron post stamped "79"-----	78.923

NEAR BRENTWOOD, WEST UP MARSH CREEK, TO MORGAN TERRITORY; THENCE NORTHWEST VIA CLAYTON TO CONCORD.

Morgan Territory, in schoolhouse yard, 55 feet east of northeast corner of schoolhouse; iron post stamped "706"-----	765.805
Marsh Creek and Mount Diablo Creek, divide between, just east of gate; iron post stamped "955"-----	955.069
Clayton, intersection of Nortonville and Marsh Creek roads with Main street, near guldepost; iron post stamped "395"-----	395.105

FROM BOUNDARY OF CONTRA COSTA AND ALAMEDA COUNTIES NORTHWEST TO DANVILLE.

Danville; railroad track south of station-----	370.5
Danville, in brick foundation of schoolhouse; bronze tablet stamped "365"-----	364.495

BYRON QUADRANGLE.

NEROLY, SOUTHEAST ALONG SOUTHERN PACIFIC RAILROAD, TO BRENTWOOD; THENCE SOUTH ALONG ROAD, TO LIVERMORE.

Brentwood, west of track at north end of platform, across tracks from store; iron post stamped "77"-----	76.890
Vascoe schoolhouse, opposite, on west side of road; iron post stamped "401"-----	401.377
Vascoe divide, east side of road; iron post stamped "970"-----	969.767

STOCKTON QUADRANGLE.^a

LATHROP, SOUTHWESTERLY ALONG SOUTHERN PACIFIC RAILROAD, TO MIDWAY.

Lathrop, 3.5 miles southwest of, 30 feet southwest of milepost 79, south side of track; iron post stamped "17.638 B"-----	17.576
Milepost 75, 10 feet north of, south side of track; iron post stamped "22.181 B"-----	22.119
Banta station, in front of freight house; top of rail-----	26.8
Milepost 72, 18 feet north of, iron post stamped "53.927 B"-----	53.865
Ellis, 1 mile west of, 4 feet north of milepost 69; iron post stamped "102.656 B"-----	102.594

ELLIS, SOUTH TO DAY'S FARM.

Ellis, 4.8 miles south of, 1,500 feet west of, at northwest angle of road to Ellis; iron post stamped "265 B"-----	264.068
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TESLA QUADRANGLE.

MIDWAY, WESTERLY ALONG SOUTHERN PACIFIC RAILROAD, TO LIVERMORE.

Midway station, 5 feet east of milepost 64; iron post stamped "351.341 B"-----	351.280
Milepost 60, 300 feet west of, south side of track, at road crossing; iron post stamped "539.602 B"-----	539.540
Altamont, 5 feet west of milepost 56; iron post stamped "739.899 B"-----	739.837
Milepost 52, 5 feet north of; iron post stamped "575.749 B"-----	575.687

^a Additional elevations on Stockton quadrangle are given on precise line (p. 15) and on primary line east of Stockton (p. 120).

PRIMARY LEVELING.

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LIVERMORE, EASTERLY VIA SOUTHERN PACIFIC RAILROAD, TO 5 MILES EAST OF CARNEGIE;
THENCE ALONG HIGHWAYS, TO DAY'S FARM.

	Feet.
T. 3 S., R. 2 E., northwest corner of sec. 23, at junction of Tesla and Mocho roads, east angle; iron post stamped "601. B"-----	601. 117
T. 3 S., R. 2 E., north side of sec. 24, south of road, nearly opposite large farm gate; iron post stamped "688 B"-----	688. 046
T. 3 S., R. 3 E., near center sec. 20, 6.5 miles west of Tesla; 0.25 mile west of Al Allen's house, south of road, near fence; iron post stamped "B 832"-----	831. 765
T. 3 S., R. 3 E., sec 27, 3.5 miles west of Tesla, half way between Old Richards mine and house, north of road; iron post stamped "B 1319"-----	1, 319. 400
Tesla, 25 feet east of entrance to Tesla Hotel; iron post stamped "No. 11, 886 B"-----	885. 053
Tesla, in brick steps of Tesla Hotel; aluminum tablet stamped "882 B"-----	881. 242
T. 3 S., R. 4 E., south side of sec. 29, 2.9 miles east of Tesla, near San Joaquin and Alameda County line, 20 feet south of track, 200 feet east of railroad culvert; iron post stamped "700 B"-----	699. 236
T. 3 S., R. 4 E., sec 35, 1.1 miles east of Carnegie, 20 feet south of track, 5 feet north of road, opposite two old shanties; iron post stamped "540 B"-----	539. 137

LIVERMORE, SOUTHEAST VIA ARROYO MOCHO, TO CORNER TS. 4 AND 5 S., R. 4 E.; THENCE
ALONG TRACY TRAIL, TO 1.1 MILES EAST OF CARNEGIE.

T. 3 S., R. 2 E., south side of sec. 36, 6.2 miles east of Livermore, near fence corner, at 48-inch oak tree, north of road; iron post stamped "784 B"-----	783. 890
T. 4 S., R. 3 E., northeast quarter of sec. 8, Mud Springs, 50 feet south of water trough, west side of road, at fence; iron post stamped "1412 B"-----	1, 412. 136
T. 4 S., R. 3 E., east side of sec. 13, 5.4 miles southeast of Mud Springs, at Fox ranch, at gate across county road, 5 feet west of road at township line; iron post stamped "2428 B 2 S"-----	2, 427. 978
T. 5 S., R. 4 E., north side, sec. 5, 600 feet south of Jones house, 20 feet west of road; iron post stamped "2415 B"-----	2, 415. 181
T. 4 S., R. 4 E., south side of sec. 10, 3.8 miles north of Corral Hollow Creek, on Hog Back at very rocky point, 6 feet east of trail; iron post stamped "2233 B"-----	2, 233. 149

PLEASANTON QUADRANGLE.

LIVERMORE, WEST ALONG ROAD, TO DUBLIN; THENCE NORTHWEST TO CONTRA COSTA-ALAMEDA
COUNTY LINE.

Livermore, in front of station; top of rail, main track-----	482.
Tassajero, junction with road to, at northwest corner; iron post stamped "346"-----	345. 877
Tassajero Valley, about 2.5 miles north of main road, on west side of Tassajero road and 2.2 feet east of monument on county line between Contra Costa and Alameda counties; iron post stamped "485" (on a spur from preceding bench mark)-----	485. 060
Dublin, intersection of center line of San Ramon road and south line of main road; iron post stamped "367"-----	366. 617
Contra Costa and Alameda counties, boundary line, 2.3 feet west of county-line monument, on east side of road; iron post stamped "425"-----	424. 770

LIVERMORE, WEST ALONG SOUTHERN PACIFIC RAILROAD, TO PLEASANTON; THENCE SOUTH TO SUNOL; THENCE WEST TO NILES; THENCE SOUTH TO IRVINGTON.

	Feet.
Livermore, 300 feet east of station, near eucalyptus tree 18 inches in diameter; iron post stamped "486 B"-----	486.153
Livermore, Farmers' Union Building, southeast corner of block north of Southern Pacific track; bronze tablet stamped "488"-----	487.496
Milepost 45, 225 feet west of, north side of track; iron post stamped "381.911 B"-----	381.873
Pleasanton, 4 feet east of milepost 42; iron post stamped "360.736 B"-----	360.723
Milepost 39, 5 feet north of; iron post stamped "297.496 B"-----	297.507
Milepost 36, 150 feet west of, on south side of track near fence; iron post stamped "227 B"-----	227.157
Farwell station, 200 feet east of; iron post stamped "167.000 B"---	167.158
Niles, in school yard, 6 feet north of west gate; iron post stamped "76.408 B"-----	76.491
Irvington, 100 feet east of Irvington Hotel, at northeast corner of fence; iron post stamped "71.631 B"-----	71.743

IRVINGTON, NORTHEAST ALONG ROAD TO LIVERMORE.

Mission Pass, 5 feet east of electric-light pole No. 3803; iron post stamped "649.800 B"-----	649.923
Sunol, 2 miles east of, 40 feet from bridge, north side of road; iron post stamped "336.986 B"-----	336.940
Livermore, 5 miles southwest of, opposite old barn on east side of road, 10 feet west of oak on north side of road; iron post stamped "609.917 B"-----	609.791

SAN JOSE QU'ADRANGLE.

IRVINGTON, SOUTH ALONG SOUTHERN PACIFIC RAILROAD, TO SAN JOSE.

Milepost 37; iron post stamped "46.563 B"-----	46.703
Milepost 40, 350 feet south of, opposite small bridge, east side of track; iron post stamped "11.301 B"-----	11.465
Milepost 43, 475 feet south of, at highway crossing, on west side of track; iron post stamped "37.505 B"-----	37.694
Milepost 46, 50 feet east of, east side of track; iron post stamped "69.117 B"-----	69.330

AT SAN JOSE.

San Jose, 150 feet east of Southern Pacific Company's standard-gage station; log bolt in circular base of iron water stand about 2 feet in diameter ^a -----	91.76
San Jose, at southwest corner of St. James and First streets, opposite St. James square, set horizontally in west end of lower edge of stone banister on north side of entrance to Santa Clara County Hall of Records; aluminum tablet stamped "98 S F"-----	98.317

^a This is a bench mark of the United States Coast and Geodetic Survey, but the elevation (given as 90.555 feet) was not accepted, as Mr. Ward's levels brought from Redwood are in a closed circuit.

PRIMARY LEVELING.

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NEW ALMADEN QUADRANGLE.

SAN JOSE, SOUTHWEST ALONG NARROW-GAGE RAILROAD, TO LOS GATOS.

	Feet.
Los Gatos, opposite station, in west corner of yard around Hotel Lindon on Santa Cruz avenue; iron post stamped "412 S F"-----	412.012

SANTA CRUZ 30' QUADRANGLE.

LOS GATOS, SOUTHWEST ALONG ROAD, TO BOULDER CREEK.

Montezuma schoolhouse, 45 feet north of, in corner of yard; iron post stamped "1459 S F"-----	1,459.074
T. 9 S., R. 2 W., at center of northeast quarter of sec. 12, 30 feet south of Brown schoolhouse; iron post stamped "2135 S F"-----	2,135.031
Bear Creek schoolhouse, 10 feet north of northwest corner of; iron post stamped "735 S F"-----	735.042
Boulder Creek, at east side of fountain in "Boulder Creek House" yard; iron post stamped "484 S F"-----	484.009

BOULDER CREEK, NORTHWEST ALONG WAGON ROAD AND TRAIL, TO IVERSON'S RANCH.

Sequoia schoolhouse, in yard at south side of stile; iron post stamped "916 S F"-----	916.025
Butano Ridge, at end of wagon road; iron post stamped "2319 S F"-----	2,318.980
Iverson's ranch, at junction of Boulder Creek and Pescadero Creek trail with road to La Honda, west side of road; iron post stamped "422 S F"-----	421.999

LA HONDA, NORTH TO DIVIDE BETWEEN ARROYA HONDA AND SANTA CLARA VALLEYS.

La Honda, north side of front entrance to hotel at steps; iron post stamped "403 S F"-----	403.021
Summit of divide, between Arroya Honda and Santa Clara valleys, in forks of road at northwest corner of saloon; iron post stamped "1680 S F"-----	1,679.450

BROWN SCHOOLHOUSE, NORTH ALONG ROAD, TO SEC. 36, T. 8 S., R. 2 W.

T. 8 S., R. 2 W., sec. 36, at junction of road leading north with reser- voir road, near county line, in Mrs. Gist's yard, at north side of gate; iron post stamped "2256 S F"-----	2,255.959
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BOULDER CREEK, SOUTH ALONG ROAD, TO SANTA CRUZ.

Ben Lomond, 10 feet from northwest corner of office of Rowardennen Hotel, in yard; iron post stamped "344 S F"-----	344.012
Felton schoolhouse, midway between two front entrances; iron post stamped "286 S F"-----	285.954
Santa Cruz, in left base of arch at entrance to court-house; alumi- num tablet stamped "18 S F"-----	18.017

PALO ALTO 15' (SANTA CRUZ 30') QUADRANGLE.

IVERSON'S RANCH, WEST ALONG PIPE LINE, TO TAR CREEK.

T. 8 S., R. 4 W., east side of sec. 1, 0.2 mile west of Tar Creek, at right of pipe-line trail, in heavy timber; iron post stamped "420 S F"-----	420.035
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IVERSON'S RANCH, NORTH TO ALPINE HOUSE; THENCE WEST TO LA HONDA.

	Feet.
Alpine schoolhouse, 0.25 mile west of, in triangle between roads at junction of Mayfield and La Honda road with Page Mill road; iron post stamped "1590 S F"-----	1,590.009

SANTA CLARA-ARROYA HONDA DIVIDE, NORTHEAST TO PALO ALTO.

Portola, junction with road to, at corner of fence surrounding E. K. Preston's house, on south side of road; iron post stamped "388 S F"-----	388.010
Leland Stanford Junior University, on south side of inner quadrangle, set next to wall on south side of west building, on top of stone ledge on west side of cellar steps; aluminum tablet stamped "89 S F"-----	88.577

REDWOOD, SOUTHEAST ALONG COUNTY ROAD, TO SAN JOSE.

Redwood, at northeast corner of Sixth and Arguello streets, opposite Southern Pacific Company's station, top of fire hydrant (C. & G. S. bench mark given as 15.412 feet above mean lower low water)----	12.312
Palo Alto, at northeast corner of station, on iron rail surrounding walk, which rail is set in brick and cement (established by the Coast and Geodetic Survey and the elevation given as 63.327)-----	63.360

CARQUINEZ, GEYSERVILLE, GUERNEVILLE, NAPA, SANTA ROSA, AND TAMALPAIS QUADRANGLES.

MARIN, NAPA, SOLANO, AND SONOMA COUNTIES.

The elevations in the following list are based mostly on a bench mark of the Coast and Geodetic Survey at Benicia Arsenal, the upper surface of a $\frac{3}{8}$ -inch iron bolt driven in a hole drilled horizontally in the southwest face of a sandstone rock at top of ledge near high-water mark at Army Point just south of railroad and east of wharf. The elevation of this is accepted as 5.980 feet above mean sea level. For additional elevations on Carquinez and Napa quadrangles refer to list by precise leveling from Benecia (p. 13).

The leveling on Carquinez and Napa was done partly in 1896 under Mr. L. C. Fletcher, topographer, by Mr. J. A. Vogelson, levelman; partly in 1899 and 1900, under Mr. Fletcher by Mr. L. D. Ryus, levelman; and partly in 1906 under Mr. E. P. Davis, assistant topographer, by Mr. C. L. Nelson. The remainder of work herein listed was done in 1899 and 1900 under Mr. Fletcher by Mr. Ryus.

CARQUINEZ 15' (NAPA 30') QUADRANGLE.

SELBY, SOUTHEAST ALONG SOUTHERN PACIFIC RAILROAD, TO MARTINEZ.

	Feet.
Port Costa, in middle of concrete column of Carquinez Market Building on Main street, near station, opposite Burlington Hotel; bronze tablet stamped "17"-----	16.787

PRIMARY LEVELING.

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Feet.

Martinez (U. S. Coast and Geodetic Survey bench mark), in brick front wall of the county building between the windows of the county clerk's and the auditor's offices; copper bolt marked on the face with the letters "U.S.C. & G.S." cut into angles of a cross (elevation accepted as given by the U. S. Coast and Geodetic Survey above half-tide level at Army Point, near Benicia)-----	27.090
Martinez court-house, U. S. Geological Survey bench mark at same place as above; bronze tablet stamped "27"-----	27.082

BENICIA, NORTHWEST TO VALLEJO.

Benicia arsenal, on brass cannon with muzzle down, used as a guard post at arsenal gate, marked "58"-----	58.098
Benicia schoolhouse, in southeast corner of foundation, east face, 2.5 feet above ground; bronze tablet stamped "35"-----	34.698
Vallejo and Sulphur Springs road, intersection with Vallejo-Benicia road, 3 miles west of Benicia, near corner of fence around Miller's ranch; iron post stamped "27 feet"-----	27.581
Vallejo, Sacramento street side of Bernard House, east of entrance, and 4 feet above sidewalk; bronze tablet stamped "44"-----	43.920

THREEMILE HOUSE, EAST TO LAKE CHABOT.

Lake Chabot, 0.5 mile east of, on Sulphur Springs road, 2.5 miles east of Threemile House, at bend of road between American Canyon road and cut-off road to Vallejo, at southwest corner of right-angle turn in road; iron post stamped "114"-----	113.678
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NAPA JUNCTION, EAST ALONG SOUTHERN PACIFIC RAILROAD, TO FAIRFIELD.

Creston station, on main east and west road north of railroad, on south side just east of northeast fence corner; iron post stamped "306"-----	306.272
Cordelia, intersection of Main street with road to Benicia, north of railroad, on south line of Main street near western side of Benicia road; iron post stamped "29 feet"-----	28.741
Fairfield court-house, 7.5 feet below bottom of stone ledge to first window of auditor's office, left of main entrance; bronze tablet stamped "15"-----	15.170

CORDELIA, NORTH UP GREEN VALLEY ROAD, TO NIGHTINGALE'S STONE HOUSE.

Nightingale's stone house, 3 miles from, in Green Valley, at north-west angle of road; iron post stamped "39"-----	39.171
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CORDELIA, SOUTH ALONG ROAD AND SOUTHERN PACIFIC RAILROAD, TO BENICIA.

Cook's ranch, east side of road just north of bridge; iron post stamped "21"-----	20.702
Goodyear station, 1.5 miles north of schoolhouse, on west side of road south of stile; iron post stamped "17"-----	17.427

FAIRFIELD, WEST ALONG ROAD TO ROCKVILLE; THENCE SOUTH TO CORDELIA.

Rockville, northeast corner of crossroads, within fence corner, opposite saloon; iron post stamped "60 B"-----	60.144
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POINT 2.8 MILES WEST OF FAIRFIELD, SOUTH TO ROAD FORK 0.5 MILE WEST OF PERRY'S HOUSE.

	Feet.
Perry's house, 0.5 mile west of; at road fork east of lane, south side of main road, in field; iron post stamped "25 B"-----	25.094

NAPA 30' QUADRANGLE.

SOBRANTE, NORTHEAST ALONG SOUTHERN PACIFIC RAILROAD, TO SELBY.

Rodeo, 180 feet west of station, south side of track, in sandstone face of railroad cut; copper bolt stamped "U.S.G.S. B.M."-----	12.665
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VALLEJO, NORTH ALONG SOUTHERN PACIFIC RAILROAD, TO NAPA JUNCTION.

Napa Junction, across tracks from hotel, near fence, on line between corral and section house, near gate leading to county road; iron post stamped "70"-----	69.942
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ROCKVILLE, NORTHEAST ALONG ROAD, TO SCARLETT'S HOUSE NEAR MANKA.

Rockville, 2.8 miles northeast of, east side of road forks, 350 feet northeast of Sam Scarlett's house, in orchard; iron post stamped "88 B"-----	88.137
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FAIRFIELD, NORTH ALONG COUNTY ROAD, TO LAGUNA CREEK; THENCE EAST TO VACAVILLE.

Tolenas Springs, fork of road, south side of gate; iron post stamped "205"-----	205.323
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C. H. Steinmetz orchard, 400 feet east of southwest corner, in solid sandstone ledge north of bend in road; copper bolt stamped "U.S. G.S. 280 Ft. B.M."-----	279.658
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VACAVILLE, WEST AND NORTH ALONG VACA AND PLEASANT VALLEY, TO WINTERS.

Alamo school, 30 feet northwest of woodshed, in grounds; iron post stamped "266"-----	265.555
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Oakdale school, northwest corner of grounds; iron post stamped "426"-----	426.308
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Pleasant Valley school, southeast corner of grounds; iron post stamped "257"-----	256.689
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Winters, 4.5 miles southwest of, north side of road, 300 feet west of house of old Finch place; iron post stamped "169"-----	169.328
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POINT 2.5 MILES WEST TO POINT 4.5 MILES WEST OF WINTERS, ON PUTAH CREEK.

Winters, 4.5 miles west of, in northwest corner of stone culvert over ravine at old Seely place; copper bolt stamped "U. S. G. S. 179 Feet B. M."-----	178.505
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SAGE CREEK, AT MOUTH OF CHILES CREEK, SEC. 6, T. 7 N., R. 4 W.

Sage Creek, at mouth of Chiles Creek, west side of bridge, in ledge of rock forming north abutment; copper bolt stamped "U. S. G. S. 280 Feet B. M."-----	279.516
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ST. HELENA, SOUTHEAST ALONG SOUTHERN PACIFIC RAILROAD, TO NAPA JUNCTION.

St. Helena, 0.5 mile south of; top of rail at switch to winery-----	236.0
Ink's house, 200 feet southeast of, 15 feet east of track, on right of way, 200 feet south of main road crossing; iron post stamped "176"-----	175.656

PRIMARY LEVELING.

131

	Feet.
Oakville, 100 feet west and 50 feet south of station, at west side of grounds against fence; iron post stamped "153"-----	153.129
Yountville, 1 mile southwest of, in brick flue of electric-light plant at Veterans' Home, 5 feet above ground; bronze tablet stamped "165"-----	165.012
Magnolia; top of rail at switch-----	90.0
Trubody, in front of station; top of rail-----	84.0
Oak Knoll school, 30 feet northwest of, in grounds next to fence; iron post stamped "100"-----	99.558
Oak Knoll, in front of station; top of rail-----	106.0
Union, opposite station, west side of road at fence; iron post stamped "75"-----	75.449
Napa, in front of station; top of rail-----	15.1
Napa, in wall at northeast corner of court-house, facing Broom street, 1 foot south of corner stone, 3.7 feet above walk; bronze tablet stamped "20"-----	20.469
Lone Tree farm, in front of station; top of rail-----	7.1
Thompson; top of rail at switch-----	7.1
Thompson station, east of railroad, south end of switch, near switch block; iron post stamped "9"-----	8.972

CORDELIA, NORTH ALONG COUNTY ROAD, TO J. W. REAM'S RANCH ABOUT 1 MILE NORTH OF COUNTY LINE.

T. 6 N., R. 3 W., about northeast corner of sec. 36 (in Chimiles unsectionized grant), about 1 mile north of county line, north side of road, 125 feet east of gate to J. W. Ream's house; iron post stamped "228"-----	227.962
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MOUTH OF SODA CREEK, SOUTH UP CAPELL VALLEY, TO CAPELL.

Burrow's house, 300 feet south of, in ledge in sidehill, south side of ravine and west of road; copper bolt marked "U. S. G. S. 641 B. M."-----	641.059
Capell, 1,200 feet west of post-office, 300 feet west of forks of road, in rocky bluff; copper bolt stamped "U. S. G. S. 872 Ft. B. M."-----	872.183

ST. HELENA, SOUTH 1 MILE ALONG COUNTY ROAD, TO MOUTH OF SULPHUR SPRINGS CANYON.

St. Helena, 1 mile south of, north side of road, against fence at center of curve, 600 feet west of northwest corner of cemetery; iron post stamped "299"-----	299.033
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YOUNTVILLE, NORTHEAST 2 MILES ALONG CAYMUS YAJOME GRANT BOUNDARY ROAD, TO CORNER.

Yountville, 2 miles northeast of, against fence on north side of road, 300 feet from forks; iron post stamped "142"-----	141.847
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NAPA, NORTHEAST ALONG COUNTY ROAD, TO CEDAR KNOLL FARM, TULUCAY GRANT.

Cedar Knoll farm, in stone gatepost at entrance; bronze tablet stamped "155"-----	155.081
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NAPA, EAST ALONG ROAD VIA INSANE ASYLUM, TO HARMONY SCHOOL.

Napa Insane Asylum, 1 mile east of; chisel mark on top of Coast and Geodetic Survey monument-----	123.56
Harmony school, 100 feet south of, 4 feet from fence; iron post stamped "121"-----	121.091

132 SPIRIT LEVELING IN CALIFORNIA, 1896 TO 1907.

NAPA, WESTERLY ALONG ROAD VIA BROWN VALLEY, TO VINEYARD.

	Feet.
Hulchica school, west side of grounds, 4 feet from fence, at west side of ravine; iron post stamped "217"-----	217.340
Vineyard, north end of station; top of rail-----	49.0

VINEYARD, NORTHWEST ALONG CALIFORNIA AND NORTHWESTERN RAILWAY, TO AGUA CALIENTE.

Sonoma, at First and Napa streets, in side wall of F. Deloring & Co.'s store, 2.7 feet above sidewalk and 5 feet north of rear door; bronze tablet stamped "83"-----	82.565
Sonoma, in front of station; top of rail-----	97.0
Caliente, in front of station; top of rail-----	130.0

SONOMA, NORTHEAST TO SEC. 31, T. 6 N., R. 5 W.

Sonoma, 2 miles east of, in ledge 4 feet high projecting from bank, 4 feet east of bank of ravine, 100 feet north and 150 feet west of road; aluminum tablet stamped "U.S.G.S. 232 Ft. B.M."-----	231.759
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VINEYARD, SOUTH ALONG CALIFORNIA NORTHWESTERN RAILWAY, TO PETALUMA CREEK.

Junction of Southern Pacific and California Northwestern railroads; top of rail-----	12.
McGill, 600 feet northeast of, 400 feet northeast of bunk house; iron post stamped "7"-----	6.654
Fairville, 1 mile west of, on north bank of Tolay Creek, at foot of hill, opposite dairy buildings; iron post stamped "40"-----	39.676
Sears Point, 150 feet west of, at north side of road, opposite draw-bridge; iron post stamped "13"-----	13.202
Reclamation, 2 miles east of, in levee 100 feet east of old railroad grade, at locks; iron post stamped "6"-----	5.121
Black Point, at drawbridge over Petaluma Creek, at southwest corner of bridge tender's house; iron T rail set in ground (U.S.C. & G.S. B.M. 14581 above lower low tide)-----	10.623

SONOMA, SOUTHWEST, TO WETMORE SCHOOLHOUSE.

Sonoma, 2.5 miles southwest of, Watmaugh schoolhouse, at southwest corner of grounds, 20 feet from south fence; iron post stamped "68"-----	67.685
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SANTA ROSA QUADRANGLE.

CALIENTE, NORTHWEST ALONG CALIFORNIA AND NORTHWESTERN RAILWAY, TO GLEN ELLEN; THENCE NORTHWEST ALONG COUNTY ROAD, TO SANTA ROSA; THENCE NORTH TO GWYN CORNER.

Sonoma, in front of station; top of rail-----	97.0
Caliente, in front of station; top of rail-----	130.0
Yulupa station, at junction with Southern Pacific Railroad; top of rail-----	165.0
Eldridge, in front of station; top of rail-----	191.0
California Home for Feeble Minded, in granite capstone at south end of entrance to Bentley Hall; bronze tablet stamped "234"-----	234.390
Glen Ellen, in front of station; top of rail-----	227.0
Dunbar school, 25 feet north and 100 feet west of, in ground near fence; iron post stamped "350"-----	350.415
Wildwood, in front of station; top of rail-----	408.0

PRIMARY LEVELING.

133

	Feet.
Kenwood public school, northeast corner of grounds; iron post stamped "412"-----	412.335
Melitta, 125 feet east of post-office, northeast side of road, 125 feet north of bridge; iron post stamped "319"-----	319.211
Santa Rosa, 2 miles east of, 150 feet west of pumping station, south of road; iron post stamped "203"-----	202.947
Santa Rosa, in north wall of court-house, 2.5 feet above pavement, at west side of steps leading to second floor, 23 feet from entrance on Fourth street side; bronze tablet stamped "165"-----	164.977

SANTA ROSA, SOUTHEAST ALONG CALIFORNIA NORTHWESTERN RAILWAY, TO PETALUMA.

Wilfred, 2 miles west of, 300 feet east of Santa Rosa and Petaluma public road, opposite road to Cotata Land Company's pasture, at northeast corner of vineyard, in ledge on side of hill; aluminum tablet stamped "215"-----	214.914
Cotata, in front of station; top of rail-----	115.
Cotata, 1,000 feet south of station, 300 feet south of warehouse, west side of track, against fence at edge of right of way; iron post stamped "117"-----	117.466
Ely, halfway between north and south end of siding, east side of railroad right of way; iron post stamped "39"-----	39.282
Corona, at road crossing; top of rail-----	31.

PETALUMA, SOUTHEASTERLY ALONG CALIFORNIA AND NORTHWESTERN RAILWAY, TO LAKEVILLE; THENCE NORTHEAST ALONG COUNTY ROADS TO WATMAUGH SCHOOLHOUSE.

Lakeville schoolhouse, on schoolhouse grounds 150 feet north of building, 125 feet east of northwest corner; iron post stamped "53"-----	53.903
Eureka schoolhouse, at northwest corner of school yard; iron post stamped "277"-----	276.436

GWYNS CORNERS, WEST ALONG CALIFORNIA NORTHWESTERN RAILWAY, TO FORESTVILLE.

Olivet, in front of station; top of rail-----	76.
Fulton, 4 miles west of, in curve, 0.5 mile north of bridge over Laguna Creek, north of track, against fence; iron post stamped "70"-----	69.937
Trenton, in front of station; top of rail-----	50.
Forestville, 150 feet west of station, 90 feet south of main track, 30 feet north of siding; iron post stamped "58"-----	57.886

RUSSIAN RIVER, VIA NORTHWESTERN PACIFIC RAILROAD, TO SAN GERONIMO.

Russian River station, 3.5 miles south of, 3.5 miles north of Occidental, 200 feet north of bridge over Howard Creek, 100 feet north of point of hill, west of track, in projecting ledge of rock; aluminum tablet stamped "184"-----	184.116
Occidental, in front of station; top of rail-----	570.3
Occidental, 0.25 mile south of, 400 feet west of Meeker schoolhouse, east of track, at point of hill; iron post stamped "562"-----	562.188
Freestone, in front of station; top of rail-----	220.
Freestone, 0.5 mile east of, 0.25 mile east of Freestone district school north side of Sebastopol road, south of house, in orchard against fence; iron post stamped "290"-----	290.202
Bodega Roads, in front of station; top of rail-----	175.
Valley Ford, in front of station; top of rail-----	43.

	Feet.
Valley Ford, 1.5 miles southeast of, 500 feet south of creek at curve, on west side of Petaluma and Valley Ford road, near fence; iron post stamped "39"-----	38.945
Valley Ford, 2 miles southwest of, dairy at point of hill on Valley Ford and Tomales road, 500 feet west of, west side of Northwestern Pacific track, at south side of road crossing; iron post stamped "138"-----	138.595
Griffin, in front of station; top of rail-----	69.
Tomales, 2 miles northeast of, 0.5 mile north of Tomales tunnel, at point of hill east of track, at north end of cut; iron post stamped "118"-----	117.857
Tomales, 500 feet south of station, on bank opposite north edge of right of way; iron post stamped "113"-----	113.697
Tomales, 2.25 miles south of, east side of road at point of hill opposite mouth of canyon across bay or channel of tide flats, set in rock bluff; aluminum tablet stamped "5"-----	5.110
Hamlet, in front of station; top of rail-----	7.
Marshall, 3 miles north of, 250 feet south of milepost 44, 50 feet south of small bridge, at east side of railroad right of way, in top of projecting ledge of rock; aluminum tablet stamped "9"-----	9.113
Marshall, 300 feet east of store and post-office, 200 feet north of Marshall Hotel, east side of siding on creek bank; iron post stamped "8"-----	8.637
Fisherman, in front of station; top of rail-----	5.0
Point Reyes, 500 feet north of station, 50 feet east of railroad at crossing, north side of public road; iron post stamped "29"-----	29.503
Point Reyes, in front of station; top of rail-----	30.
Point Reyes, 2.25 miles northeast of north bend, in front of Mr. Galger's house, 300 feet west of front gate, on north side of track, against hedge fence; iron post stamped "46"-----	46.832
Tocaloma, 400 feet north of station, 150 feet west of Paper Mill Creek, at south end of cut in bank, west of railroad track; iron post stamped "86"-----	86.068
Tocaloma, in front of station; top of rail-----	86.
Taylorville, in front of paper mill; top of rail-----	121.
Camp Taylor, in front of station; top of rail-----	137.
Camp Taylor, 300 feet north of bridge at Camp Taylor Hotel, 150 feet from Paper Mill Creek, 100 feet west of clubhouse, on east side of track; iron post stamped "137"-----	137.984
San Geronimo, 0.25 mile north of, at north end of small cut in point of hill, east of railroad against fence, on west side of road; iron post stamped "285"-----	285.970
San Geronimo, in front of station; top of rail-----	305.
SAN RAFAEL, NORTH ALONG SAN FRANCISCO AND NORTH PACIFIC RAILROAD, TO PETALUMA.	
Novata, 600 feet south of, 600 feet north of Creamery, 100 feet south of switch at south end of siding, against fence at line of railroad right of way, west of track; iron post stamped "16"-----	17.088
Novata, in front of station; top of rail-----	11.0
Burdell, 125 feet north of station, 150 feet east of rock bluff; iron post stamped "7"-----	7.995
Petaluma, 3 miles south of, at point of hill 200 feet west of track, at foot of small knoll 30 feet west of marsh, 100 feet east of 4-foot rock projecting above ground; iron post stamped "5"-----	6.298

PRIMARY LEVELING.

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BODEGA STATION, VIA COUNTY ROAD, TO BODEGA.

	Feet.
Bodega station, 0.25 mile north of, north of intersection of Valley Fork road with Freestone and Bodega road, against fence, at Bodega road corner; iron post stamped "169"-----	169.318
Bodega schoolhouse, against division fence between schoolhouse and church, 30 feet southwest of building; iron post stamped "145"--	145.405

POINT REYES STATION, VIA COUNTY ROAD, TO REGALLOS RANCH.

Point Reyes, 1.25 miles south of, on Olema road 400 feet east of slough, south side of road; iron post stamped "14"-----	14.726
Inverness, 1 mile west of, at foot of hill known as "Light-house Grade," against fence north of road, at gate; iron post stamped "12"-----	12.843
Inverness, 3 miles northwest of, 0.5 mile west of summit of hill, opposite gate to Mr. Regallos's ranch, south side of road; iron post stamped "202"-----	202.063

NOVATA, WEST ALONG COUNTY ROAD (3-MILE SPUR LINE).

Novata, 3 miles west of, in open space opposite and 1,000 feet south of point of hill, at south side of road, against fence; iron post stamped "108"-----	108.707
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PETALUMA, VIA COUNTY ROAD, TO WILSON AND MARIN SCHOOLS.

Petaluma, City Hall, in wall of main building, 2 feet from north-east corner, facing Kentucky street, 1.9 feet above pavement; bronze tablet stamped "17"-----	16.700
Wilson schoolhouse, at southeast corner of school yard; iron post stamped "81"-----	80.664
Petaluma, 3 miles west of, 0.5 mile west of Marin schoolhouse, 0.5 mile north of public road running over ridge west from Petaluma, at foot of hill south side of canyon, 150 feet west of fence on township line, in sec. 1, T. 4, R. 8 W.; iron post stamped "248"-----	247.628

ELY, WEST ALONG COUNTY ROADS, TO LIBERTY SCHOOL.

Ely, 2.5 miles west of, Liberty schoolhouse, at south side of school grounds, opposite forks of road, opposite cemetery; iron post stamped "103"-----	102.765
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BELLVIEW STATION, WEST ALONG COUNTY ROAD, TO TODD SCHOOL; THENCE SOUTH TO STONY POINT SCHOOL.

Todd district schoolhouse, at front fence, 20 feet south of gate; iron post stamped "92"-----	91.775
Stony Point district school, 50 feet south of building, set in ground against fence; iron post stamped "96"-----	96.217

SANTA ROSA, VIA CALIFORNIA NORTHWESTERN RAILROAD, TO SEBASTOPOL.

Santa Rosa, 3 miles west of, Wrights schoolhouse, at northwest corner of grounds; iron post stamped "93"-----	93.075
Sebastopol, 600 feet north of, opposite large warehouse, against fence, east of track; iron post stamped "63"-----	63.481

TAMALPAIS QUADRANGLE.

SAN GERONIMO, SOUTHEAST ALONG NORTH PACIFIC COAST RAILROAD, TO SAN RAFAEL.

	Feet.
Fairfax, in front of station; top of rail-----	109.0
San Rafael, North Shore Railway station, foot of northeast corner of shed over track, northeast corner of cap (Coast and Geodetic Survey bench mark, 12.175 feet above mean lower low tide)-----	7.790

GEYSERVILLE QUADRANGLE.

GWYNS CORNERS, NORTHEASTERLY, TO CALISTOGA; THENCE SOUTHEAST TO ST. HELENA.

Burk's sanitarium, 30 feet west of entrance, north side of road; iron post stamped "210"-----	210.350
Tarwater school, 0.1 mile southwest of, at west side of road forks; iron post stamped "490"-----	490.118
Tarwater Hill summit, east of road at fence in front of old cabin; iron post stamped "1050"-----	1,050.292
Franz Valley school, 1 mile northeast of, south of road at summit on county line; iron post stamped "970"-----	970.456
Calistoga, 25 feet west of southwest corner of Lincoln avenue and Main street, in sidewalk; iron post stamped "354"-----	353.679
Calistoga, 4 miles southeast of, in center of cap at east side of stone bridge over Ritchie Creek; bronze tablet stamped "338"-----	338.389

FORESTVILLE, NORTHWEST ALONG CALIFORNIA NORTHERN RAILWAY, TO HILTON; THENCE
WEST TO GUERNEVILLE.

Mesa Bell Park; rail at-----	59.
Camp Six, in front of station; top of rail-----	66.
Hilton post-office, in front of; top of rail-----	66.
Hilton post-office and station, 300 feet southwest of trestle, foot of T. P. Brown's orchard, at fence; iron post stamped "65"-----	65.005
Korbell, in front of station; top of rail-----	62.

GUERNEVILLE QUADRANGLE.

GUERNEVILLE, SOUTHWEST ALONG CALIFORNIA NORTHWESTERN RAILWAY, TO RUSSIAN RIVER.

Guerneville, 0.5 mile west of, 30 feet west of road, 50 feet from rail- road, south of crossing 300 feet, at point of hill at head of road; iron post stamped "46"-----	46.540
Guerneville Park, in front of station; top of rail-----	44.
Russian River, in front of station; top of rail-----	38.

RUSSIAN RIVER, WEST ALONG NORTH SHORE RAILROAD, TO KIDD CREEK STATION.

Mesa Grand, in front of station; top of rail-----	40.
Moscow Cottage; top of rail-----	64.
Duncan's mill, west of railroad company's hotel, 1,500 feet southwest of roundhouse, at point of hill, 100 feet west of county road, on side of hill, in projecting ledge of rock; aluminum tablet stamped "44"-----	44.051
Kidd Creek, 800 feet south of, 600 feet south of mouth of Kidd Creek, in side of hill west of track, in projecting ledge of rock; aluminum tablet stamped "53"-----	53.113

DUNCAN'S MILL, VIA CALIFORNIA NORTHWESTERN RAILWAY AND COUNTY ROAD, TO JENNER GULCH.

	Feet.
Duncan's mill, 3 miles west of, mouth of Willow Creek, 200 feet west of forks of wagon road, 125 feet northeast of track; iron post stamped "23"-----	23. 228
Markhams post-office, 3 miles west of, 400 feet from Russian River, 100 feet north and 20 feet above wagon road, west side of Jenner Gulch, in ledge of rock projecting from hillside; aluminum tablet stamped "56"-----	56. 009

RODEGA, WEST 3 MILES.

Bodega, 3 miles west of, 1,500 feet east of Mrs. Quinlan's house, 75 feet north of road opposite gulch; iron post stamped "88"-----	87. 946
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RIO VISTA AND VACAVILLE QUADRANGLES.

CONTRA COSTA, SACRAMENTO, SAN JOAQUIN, AND SOLANO COUNTIES.

The elevations in the following list are based upon the precise-level line Benicia to Sacramento, which crosses Vacaville quadrangle and are checked upon a gage bench mark at Black Diamond landing.

The leveling on Antioch, Courtland, and Rio Vista quadrangles was done partly in 1905 under Mr. R. B. Marshall, geographer, by Mr. R. A. Farmer, topographer, and partly in 1906 by C. L. Nelson, and some leveling on Antioch quadrangle was done in 1896 under Mr. L. C. Fletcher by Mr. J. A. Vogelsson. The leveling on Vacaville quadrangle was done under Mr. Marshall, partly in 1904 by Messrs. R. A. Farmer and C. H. Semper and partly in 1905 by Mr. Farmer.

NOTE.—The elevations of certain bench marks on the Courtland and Rio Vista quadrangles have been corrected by the precise-level line run by L. F. Biggs in fall of 1907 from Sacramento down the river to west edge of Rio Vista quadrangle.

COURTLAND QUADRANGLE.

GLIDE GUN CLUB, SOUTH ALONG RIGHT SIDE OF SACRAMENTO RIVER, TO CLARKSBURG.

	Feet.
Glide Gun Club, 0.5 mile south of, on line between Glide and Content, 300 feet south of Manual Content's house, 150 feet west of levee, 20 feet south of southwest corner of woodhouse; iron post stamped "16 B"-----	16. 012
Anton Fernande's house, 40 feet from southeast corner of, west side of road, northeast corner of house lot; iron post stamped "21 B"-----	20. 852
Clarksburg, 0.5 mile north of, 100 feet east of Merrit schoolhouse, inside of fence; iron post stamped "14 B"-----	14. 263
TREMONT, EAST 4 MILES; THENCE SOUTH 6.5 MILES; THENCE EAST 2 MILES; THENCE SOUTH 3 MILES; THENCE WESTERLY TO BINGHAMTON.	
Bulkey's ranch house, at southeast corner of yard, west side of road; iron post stamped "34 B"-----	34. 123
Hance Timm's house, 400 feet southeast of, west side of road; iron post stamped "31 B"-----	31. 334

	Feet.
Jud King's ranch house, 0.5 mile west of, southeast corner T. 7 N., R. 2 E., southeast corner of field; iron post stamped "21 B"-----	20.708
T. 6 N., R. 2 E., near northeast corner of sec. 24, southeast corner to pasture fence; iron post stamped "8 B"-----	7.409
T. 6 N., R. 2 E., 1 mile east by 0.25 mile north of Peters's house, southeast corner of field; iron post stamped "17 B"-----	17.121

JUD KING'S RANCH HOUSE, 2 MILES EAST (DOUBLE SPUR LINE).

Jud King's ranch house, 2 miles east of, on north and south fence line, 50 feet east of levee, 150 feet southeast of dead tree on levee; iron post stamped "9 B"-----	8.777
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FORKS OF SUTLER AND STEAMBOAT SLOUGHS, NORTH VIA COURTLAND, TO CLARKSBURG.

Forks of Sutler and Steamboat sloughs, 0.7 mile north of, 0.25 mile northwest of H. M. Donaldson's ranch house, 300 feet west of Sutler Slough, in northwest corner of Orchard lot; iron post stamped "6 1906 BN"-----	5.916
Courtland, 2 miles north of, 20 feet east of road, 150 feet west of drainage canal, 260 feet north of levee; iron post stamped "10 1906 B N"-----	9.900
Clarksburg, 2.2 miles south of, 40 feet southeast of Ross House, west of road, 200 feet west of Sacramento River; iron post stamped "19 1906 B N"-----	19.006

COURTLAND, SOUTHEAST, TO WALNUT GROVE.

Courtland, 60 feet east of road, in south foundation of Baner, Miller & Newbert's store; aluminum tablet stamped "14 BN 1906"-----	13.755
Grand Island, at head of Steamboat Slough, 0.5 mile north of bridge; zero of gage at Kerchwak House-----	-4.398
Grand Island Bridge, north corner of bridge abutment; aluminum tablet stamped "20 B N 1906"-----	19.696
Schoolhouse, 100 feet southeast of, 0.25 mile northwest of pump house, at southeast corner of yard, west side of road; iron post stamped "-2 B N 1906"-----	-2.498
Grand Island Bridge, 3.5 miles south of, 250 feet southeast of E. B. King's house, 150 feet northeast of Sacramento River levee, 100 feet northwest of cross levee; iron post stamped "8 1906 BN"-----	7.851

VACAVILLE QUADRANGLE.

BINGHAMTON, WEST ALONG HIGHWAY, TO ELMIRA.

Binghamton post-office, 5 feet east of northeast corner of; iron post stamped "35 B"-----	34.569
T. 6 N., R. 1 E., near quarter corner between secs. 28 and 27, west side of road at southeast corner of field; iron post stamped "44 B"-----	43.783
Elmira, 200 feet north of, 40 feet west of track, 8 feet north of telegraph pole; iron post stamped "72 B"-----	72.247
Elmira, 1.7 miles north of, 33 feet east of track, 2 feet west of mile-post 62; iron post stamped "62 B"-----	62.282

PRIMARY LEVELING.

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SEC. 36, T. 5 N., R. 1 E., NORTHEAST TO CENTER OF T. 6 N., R. 2 E.

	Feet.
T. 5 N., R. 1 E., northeast corner sec. 13, west side of road; iron post stamped "15 B"-----	14. 660
Main Prairie, 200 feet north of old hotel, 100 feet west of barn, west side of road; iron post stamped "7 B"-----	7. 037

CANNON, ALONG WAGON ROAD, TO TRIANGULATION STATION.

Triangulation station, 400 feet east of railroad, 0.5 mile northwest of Cannon; iron post stamped "163 B"-----	163. 382
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WINTERS, SOUTH ALONG SOUTHERN PACIFIC RAILROAD, TO ELMIRA.

Wolfskill station, at signboard; top of east rail-----	123. 8
Allendale, in front of station; top of west rail-----	119. 9
Allendale, 350 feet south of signboard, west of track and south of road crossing, 10 feet north of telegraph pole; iron post stamped "117 B"-----	117. 056
Hartley, 400 feet south of signboard at station, east side of track and north of road crossing; iron post stamped "115 B"-----	115. 067
Violet, in front of station; top of west rail-----	139. 1
Vacaville station, 350 feet west of track, north of street, 8 feet east of telephone pole, at corner of railroad lot; iron post stamped "164 B"-----	164. 138
Vacaville, at northwest corner of public schoolhouse, 4 feet above ground; bronze tablet stamped "188 B"-----	187. 717
Vacaville, in front of station; top of west rail-----	161. 9
Elmira, 200 feet north of station, 40 feet west of track, 8 feet north of telephone pole; iron post stamped "72 B"-----	72. 247
Elmira, 1.7 miles north of, 33 feet east of track, 2 feet west of mile-post 62; iron post stamped "62 B"-----	62. 282

TREMONT, WEST VIA CURRY SCHOOLHOUSE, TO NEAR WOLFKNILL.

Curry school, at northwest angle of crossroads; iron post stamped "85 B 1904 2"-----	85. 018
Curry school, 3.7 miles west of, southeast angle of crossroads; iron post stamped "103 B"-----	103. 139

DIXON, WEST VIA COUNTY ROAD, TO ALLENDALE.

Dixon, 700 feet south of station, west of track, at road crossing, south of road, at corner of fence; iron post stamped "61 B"-----	61. 295
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ANTIOCH QUADRANGLE.

FAIRFIELD COURT-HOUSE, EAST ALONG WAGON ROAD, TO POINT 1 MILE NORTH OF DENVERTON; THENCE TO DENVERTON; THENCE EAST TO SEC. 36, T. 5 N., R. 1 E.

Fairfield court-house, 2.75 miles east of, 100 feet east of water tank, on south side of road; iron post stamped "15 B"-----	14. 704
T. 5 N., R. 1 W., sec. 29, southeast corner of (set probably in 1896)---	14. 788
Denverton, 5 feet west of northwest corner of blacksmith shop, in front of schoolhouse; iron post stamped "7 B"-----	6. 564
T. 5 N., R. 1 E., northeast corner sec. 36, east side of road; iron post stamped "17 B"-----	17. 261

SEC. 29, T. 5 N., R. 1 W., SOUTH TO POTRERO HILLS.

Potrero Hills, on section line between secs. 3 and 4, 0.5 mile south of north line of section, opposite gate to Sylvester Pimental's ranch, 5.5 miles east to Sulsum; iron post stamped "49"-----	Feet. 49.064
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DENVERTON, SOUTH ALONG WAGON ROAD, TO NEAR BIRDS LANDING; THENCE EASTERLY TO PETER ANDERSON'S PLACE.

Montezuma schoolhouse, southeast corner of yard, west of road; iron post stamped "41 B"-----	41.245
Willow Springs schoolhouse, southeast corner of yard, west side of road; iron post stamped "58 B"-----	57.666
Birds Landing, 5 miles southeast of, at Peter Anderson's place, 10 feet west of gate to barn, on south side of road; iron post stamped "110 B"-----	110.131

SEC. 35, T. 5 N., R. 1 E., SOUTHEAST TO SEC. 9, T. 4 N., R. 2 E.

T. 4 N., R. 2 E., corner secs. 3, 4, 9, and 10, 300 feet southwest of M. Egbert's white house, west side of road; iron post stamped "32 B"-----	31.957
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CONCORD, NORTH ALONG ROAD TO BAY POINT; THENCE EAST ALONG SOUTHERN PACIFIC RAILROAD, TO BLACK DIAMOND.

McAvoy's siding, in corner of fence southwest from southwest corner of warehouse; iron post stamped "22"-----	22.439
Black Diamond, at corner of stable; iron post stamped "21"-----	20.500
Black Diamond Hotel, tack on porch of, midway between two doors, 4 inches from side of house "-----	7.500

CORNWALL, EAST ALONG SOUTHERN PACIFIC RAILROAD, TO ANTIOCH.

Antioch schoolhouse, in rear wall of foundation; bronze tablet stamped "35"-----	35.296
Antioch, in front of station; top of rail-----	43.5

SIX MILES SOUTHWEST OF RIO VISTA, EAST AND SOUTH ALONG ROAD, TO TOLANDS LANDING; THENCE WEST TO FORKS OF ROAD 1.5 MILES SOUTH OF BIRDS LANDING.

Tolands Landing, 3 miles west of, north side of road, 1 foot south of fence line, 8 feet east of gate, 0.25 mile west of feeding shed, 100 feet north of slough; iron post stamped "10 B"-----	9.874
Collinsville, 0.5 mile north of, southwest corner of schoolhouse, at crossroads; iron post stamped "5 B"-----	4.927

TOLANDS LANDING, SOUTH ACROSS SHERMAN ISLAND, TO NORTH BANK SAN JOAQUIN RIVER; THENCE WEST TO ANTIOCH.

Tolands Landing, 3.9 miles south of, at south end of road which crosses Sherman Island southward from Tolands Landing, at turn, 0.5 mile south from pump house, 100 feet north of San Joaquin River, south side of road, 0.25 mile east of house; iron post stamped "—1 1906 BN"-----	—1.477
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"The above bench mark is, as nearly as could be determined, the datum of the level system of the State engineering department, the elevation of which above the mean "lowest low tide," as resulting from tidal observations made at New York Landing during the months of October, November, and December, 1878, is 11.22 feet. From tide tables, mean sea level is 3.7 above lowest low water at Antioch.

RIO VISTA QUADRANGLE.

ANDERSON'S PLACE, NORTHEAST TO RIO VISTA; THENCE NORTHWEST TO NORTHEAST CORNER
SEC. 9, T. 4 N., R. 2 E.

	Feet.
Madison's blacksmith shop, 100 feet from southwest corner of, north-west corner of field, and east side of road; iron post stamped "54 B"-----	53.822
Rio Vista Bank Building, southeast corner, 2 feet above sidewalk; tablet stamped "23 B"-----	22.425
T. 4 N., R. 2 E., corner secs. 11, 12, 13, and 14, east side of road; iron post stamped "19 B"-----	18.900

RIO VISTA, NORTH BY STEAMBOAT SLOUGH AND SUTTER SLOUGH, TO FORK OF SUTTER AND
STEAMBOAT SLOUGH.

Ferry landing; zero of gage-----	— 4.403
Rio Vista, 3.7 miles north of, 0.8 mile south of Westgates, 250 feet west of river, 200 feet west of house on north side of road; iron post stamped "—1 B N 1906"-----	—1.130
Walkers Landing, 0.7 mile north of, west side of road, 150 feet west of Steamboat Slough, 250 feet northwest of J. Hollenbeck's house; iron post stamped "4 1906 B N"-----	3.600

WALNUT GROVE, SOUTH ALONG EAST SIDE TYLER ISLAND AND WEST, TO RIO VISTA.

Tyler Island, east side of road across island, 200 feet west of Mokelumne River, on ranch "J" of Bamman property, 0.25 mile south of pump house; iron post stamped "—1 N 1906"-----	—1.088
Camp C, 140 feet east of house, 100 feet north of Mokelumne River, 100 feet northwest of barn; iron post stamped "0 1906 B N"-----	—0.282
Ferry landing to Tyler Island, 150 feet west of, north side of road, 50 feet west of saloon; iron post stamped "3 1906 B N"-----	3.040
G. F. Terschman's house, 85 feet west of, 200 feet south of Sacramento River; iron post stamped "5 B N 1906"-----	4.943

CAPAY, DAVISVILLE, DUNNIGAN, FAIROAKS, KNIGHTS LANDING, POPE VALLEY, RUMSEY, AND
WOODLAND QUADRANGLES.

COLUSA, NAPA, PLACER, SACRAMENTO, SUTTER, AND YOLO COUNTIES.

The elevations in the following list are based upon the precise-level lines along the Southern Pacific Railroad from Benicia via Sacramento to Mohave and from Davisville north to State line.

The leveling on Fair Oaks quadrangle was done in 1901 under Mr. A. E. Murlin, topographer, by Mr. L. D. Ryus, levelman, and that on Davisville quadrangle was done in 1905 under Mr. R. B. Marshall, geographer, mostly by Mr. G. C. Douglas, levelman, but partly by R. A. Farmer, topographer. The leveling on the Woodland quadrangle was done in 1904 by Messrs. Farmer and C. H. Semper.

The work on Dunnigan quadrangle was done in 1904 by Mr. Semper, that on Knights Landing quadrangle was done in 1904 by

Mr. Semper and in 1905 by Mr. Douglas, and that on Rumsey quadrangle in 1904 by Messrs. Farmer and E. M. Fry. That on Capay and remainder of Pope Valley 30' quadrangle was done under Mr. L. C. Fletcher, partly in 1899 by L. D. Ryus, levelman, and partly in 1904 by Mr. Farmer.

FAIROAKS QUADRANGLE.

SACRAMENTO, NORTHEAST TO SAN JUAN SCHOOL; THENCE TO FAIROAKS; THENCE SOUTH TO SOUDAN; THENCE SOUTHWEST ALONG SOUTHERN PACIFIC RAILROAD TO ROUTIER; THENCE SOUTH TO WALSH STATION; THENCE NORTHWEST ALONG SOUTHERN PACIFIC RAILROAD, TO BRIGHTON.

	Feet.
Sacramento, in north wall of post-office, 15 feet east of northwest corner, 5 feet above ground; aluminum tablet stamped "31 B"-----	30.527
Sacramento, State capitol, 3 miles northeast of, at intersection of roads; iron post stamped "39 B"-----	39.320
Ben Ali, 2.5 miles east of, 150 feet west of windmill, at intersection of roads; iron post stamped "69 B"-----	68.650
San Juan schoolhouse, 1 mile east of, at southeast corner of field, at intersection of roads; iron post stamped "191 B"-----	190.625
Fairoaks Junction, 300 feet east of switch, at southeast corner of field, north of track; iron post stamped "113 B"-----	112.937
Router, opposite station, north of county road; iron post stamped "69 B"-----	68.754
Walsh, at southwest corner of field, opposite saloon; iron post stamped "64 B"-----	63.937

SACRAMENTO, NORTH ALONG MARYSVILLE ROAD, TO FORKS OF ROADS AT NORTHWEST CORNER OF SEC. 19, T. 10 N., R. 5 E.; THENCE EAST TO QUARTER CORNER SOUTH SIDE OF SECTION 10, T. 10 N., R. 6 E.; THENCE SOUTHERLY TO FAIROAKS.

Sacramento Capitol, 5 miles north of, 250 feet north of house, 100 feet west of corner at L. of road; iron post stamped "28 B"-----	27.933
T. 10 N., R. 5 E., northwest corner of sec. 19, at intersection of road running east from main road; iron post stamped "31 B"-----	30.862
T. 10 N., R. 5 E., southwest corner of sec. 13, 1 mile south of Centre Union schoolhouse, east side of road, at angle to north; iron post stamped "89 B"-----	88.898
Antelope, 2 miles northeast of, at edge of Southern Pacific Railroad right of way, north of road at crossing, west of track; iron post stamped "146 B"-----	146.101
T. 10 N., R. 6 E., near center sec. 25, at southeast corner of cross-roads; iron post stamped "151 B"-----	151.212

DAVISVILLE QUADRANGLE.

SACRAMENTO, NORTHWEST ALONG HIGHWAY, TO WOODLAND.

Sacramento, west of, south side of track at milepost 86; iron post stamped "17 B"-----	17.339
Elkhorn, 7.7 miles south of, water tank on east side of levee road, in front of Lehman's hop yard, 3 feet north of foundation to tank; iron post stamped "32 B"-----	32.138
Elkhorn, 3.9 miles south of, northwest corner of foundation to Taylor monument; small cross cut in granite block set in brick, marked "U. S. G. S. 29"-----	28.87

PRIMARY LEVELING.

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Feet.

Elkhorn, 2.8 miles south of, west corner cement-foundation water tank on levee opposite John Merkley's place; aluminum tablet stamped "32 B"-----	32.015
Elkhorn, southwest corner of stone house by watering trough, on road to Woodland; iron post stamped "27 B"-----	26.785
Elkhorn, 3.6 miles west of, south side of road, 340 feet east of section corner; iron post stamped "23 B"-----	23.035

AT GRAYS BEND.

Knights Landing, 6.1 miles southeast of, 200 feet northwest of Mr. Weisman's house at Grays Bend, west side of road, at foot of levee; iron post stamped "29 B"-----	29.163
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ELKHORN WEIR TO ELKHORN.

Elkhorn, 3 miles north of, 400 feet north of Dillon's house, 50 feet west of levee, on fence line; stone monument (U. S. B. M. 69)-----	25.539
Elkhorn, 2.9 miles north of, 200 feet south of Dillon's house, at north end of Elkhorn Weir, top of west end of wall; aluminum tablet stamped "30 B"-----	30.090
Elkhorn, 2.9 miles north of, 60 feet south of Dillon's house, stone monument (U. S. B. M. 70)-----	29.99

SACRAMENTO, SOUTH ON RIGHT BANK OF SACRAMENTO RIVER, TO GLIDE GUN CLUB.

Broderick, 3 miles south of, west side of road in front of hop storage house of Perry's place, iron post stamped "29 B" ^a -----	28.671
Machardo's house, 300 feet south of, 20 feet south of road; iron post stamped "22 B" ^a -----	22.315

WOODLAND QUADRANGLE.

YOLO, SOUTH ALONG SOUTHERN PACIFIC RAILROAD, TO WOODLAND.

Yolo, 150 feet north of station, north of road; iron post stamped "74 B"-----	72.922
Yolo, 0.8 mile south of, north abutment of bridge over Cache Creek, west end, top of parapet wall; aluminum tablet stamped "89 B"-----	89.425
Woodland, 2.2 miles north of, north of road, 250 feet east of track, at southwest corner of Taylor Bros.' farm; iron post stamped "64 B"-----	63.986
Woodland, at Southern Pacific Railroad station, southeast corner of railroad park, 5 feet north of water tank; iron post stamped "60 B"-----	60.260
Woodland, southeast corner of Yolo County Savings Bank; aluminum tablet stamped "71 B"-----	70.734

YOLO, WEST VIA COUNTY ROAD, TO FORKS OF ROAD 1 MILE WEST OF BLICKLEY RANCH.

Yolo, 3.9 miles west of, on north of road at gate leading to Fred Market's ranch house; iron post stamped "169 B"-----	169.283
Yolo, 7.4 miles west of, at southeast angle of crossroads, 650 feet south of J. C. Holverstott's ranch house; iron post stamped "169 B"-----	169.168

^a Elevation corrected by precise-level line of L. F. Biggs in fall of 1907.

WOODLAND, WEST, TO MADISON.

	Feet.
Woodland station, 8 feet north of water tank; iron post stamped "60 B"-----	60.260
Woodland, 4.4 miles west of, in south face of northwest monument Yolo Base, U. S. Coast and Geodetic Survey, stamped "155 B"-----	155.033
Woodland, 5 miles west of, on east line of Guersisosi grant; iron post stamped "108 B"-----	108.011
Madison, in front of station; top of east rail-----	143.5
Madison, 200 feet southwest of station, south of Main street, 8 feet west of telephone pole; iron post stamped "150 B"-----	150.026

MADISON, SOUTH ALONG SOUTHERN PACIFIC RAILROAD, TO WINTERS.

Citrona, in front of station; top of west rail-----	162.6
Citrona, 60 feet west of warehouse, west side of road; iron post stamped "162 B"-----	162.056
Ely in front of station; top of west rail-----	174.0
Ely, 100 feet west of warehouse, 60 feet west of signboard, west side of road; iron post stamped "175 B"-----	175.004
Winters, 200 feet south of station, 40 feet west of track, 50 feet east of street; iron post stamped "131 B"-----	131.011
Winters, in front of station; top of west rail-----	130.9

FRENCH PLACE, NORTHEAST, TO WINTERS AND RETURN.

Winters, 10 feet from fence, at west side of public school grounds; iron post stamped "133 B"-----	132.843
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3.2 MILES NORTH OF DAVISVILLE, WEST ALONG COUNTY ROAD, TO ELY.

Davisville, 3.2 miles north of, 30 feet north of milepost 80; iron post stamped "48 B"-----	48.400
Plainfield, southeast angle of crossroads; iron post stamped "70 B"-----	69.932
Plainfield, 3 miles west of, at signboard, northwest angle of crossroads; iron post stamped "90 B"-----	90.131

CROSSROADS 3 MILES WEST OF PLAINFIELD, NORTH ALONG COUNTY ROAD, TO NORTHWEST MONUMENT COAST AND GEODETIC SURVEY, YOLO BASE.

Stoddard schoolhouse, 3.4 miles north of, at northeast angle of crossroads; iron post stamped "96 B"-----	95.942
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CROSSROADS 3 MILES WEST OF PLAINFIELD, SOUTH VIA COUNTY ROAD TO CURRY SCHOOLHOUSE.

Fairfield schoolhouse, 1 mile south of, northeast angle of crossroads, at fence; iron post stamped "92 B"-----	91.853
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ONE MILE SOUTH OF FAIRFIELD SCHOOLHOUSE, EAST AND SOUTH, TO COAST AND GEODETIC SURVEY MONUMENT.

Miller ranch, north bank of Putah creek, Coast and Geodetic Survey monument, north face; aluminum tablet stamped "74 B"-----	73.901
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CAPAY (POPE VALLEY 30') QUADRANGLE.

POINT 4.5 MILES WEST OF WINTERS, WESTERLY, TO SODA CREEK.

Corner stone, Yolo, Solano, and Napa counties, north bank of Putah Creek, on bench east side of rock 3 inches below top; copper bolt stamped "U. S. G. S. 212 Ft. B. M."-----	212.272
Wragg Canyon, east of, at fork of road; iron post stamped "306"---	306.128

PRIMARY LEVELING.

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Monticello, 1.25 miles south of, in top of stone tablet in center of south side of Monticello stone bridge over Putah Creek; bronze tablet stamped "309"-----	Feet. 308.643
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TANCRED, SOUTH, TO CAPAY.

Cadnassa, 400 feet north of station, east of track, on right of way line, at northwest corner of field; iron post stamped "333 B"-----	333.354
Capay, in front of station; top of south rail-----	215.0

SEC. 36, T. 11 N., R. 2 W., SOUTH TO CAPAY.

Intersection of Capay-Grant range line between Rs. 1 and 2 W., 10 feet north of; iron post stamped "191 B"-----	191.216
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MADISON, WEST ALONG SOUTHERN PACIFIC RAILROAD, TO CAPAY.

Esparto, southeast corner of post-office building, 18 inches above ground, in east wall, 18 feet south of corner; tablet stamped "190 B"-----	190.047
Capay, southeast corner of yard limits, north side of Main street, west of road from Dunnigan; iron post stamped "203 B"-----	203.432

RUMSEY (POPE VALLEY 30') QUADRANGLE.

ARBUCKLE, SOUTHEAST, TO HERSHEY.

Arbuckle, 4.6 miles south of, east of track at road crossing, 1,100 feet north of milepost 110, at Widow Spencer's ranch; iron post stamped "139 B"-----	138.694
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CORNER TS. 13 AND 14 N., RS. 2 AND 3 W., SOUTH AND EAST TO DUNNIGAN.

Liggett ranch house, 0.5 mile west of, 50 feet northwest of northwest corner sec. 16, T. 13 N., R. 3 W., 100 feet south of creek, north side of road; iron post stamped "308 B"-----	308.027
Wildwood schoolhouse, 50 feet northwest of, 20 feet south of county line, between Yolo and Colusa counties; iron post stamped "304 B"-----	304.147
Dunnigan, 2 miles north by 3 miles west of, 300 feet north of creek, 150 feet northeast of house, 5 feet east of gate; iron post stamped "195 B"-----	195.168

SAND CREEK SCHOOLHOUSE, SOUTHWEST ALONG ROAD VIA OLD OIL WELLS, TO RUMSEY.

Old oil wells, 400 feet north of, 400 feet northwest of old stock shed, 10 feet north of road, 50 feet north of Sand Creek; iron post stamped "583 B"-----	583.109
Rumsey, 4 miles north of, on summit of divide between Cache and Sand creeks, 10 feet east of road; iron post stamped "1350 B"-----	1,350.121

RUMSEY, VIA SOUTHERN PACIFIC RAILROAD, TO TANCRED.

Rumsey, in front of station; top of east rail-----	419.1
Rumsey, 250 feet southeast of station, 100 feet west of barn, on line between railroad and farm; iron post stamped "418 B"-----	418.292
Guinda, in front of station; top of rail-----	353.7
Guinda, 125 feet northwest of station, 60 feet southeast of hotel; iron post stamped "353 B"-----	353.240
Tancred, 120 feet north of station, 50 feet east of track; iron post stamped "296 B"-----	296.234

NEAR BRIMLEY'S RANCH, SOUTH ALONG ROAD TO NORTHWEST CORNER SEC. 36, T. 11 N., R. 2 W.

	Feet.
Fairview schoolhouse, 40 feet south of northwest corner of, 60 feet east of road; iron post stamped "342 B"-----	342.285
T. 11 N., R. 2 W., northwest corner sec. 36, 1 mile east of schoolhouse, northeast corner of field, southwest corner of crossroads, 4 feet south of corner post; iron post stamped "236 B"-----	236.686

POPE VALLEY 30' QUADRANGLE.^a

SODA CREEK, WEST-NORTHWEST TO NEAR MOONEY'S RANCH; THENCE SOUTHWESTERLY TO MOUTH OF CHILES CREEK.

Mooney's ranch, 1 mile west of, north side of road at summit, 100 feet west of road to Priet's house; iron post stamped "991"-----	991.170
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SAGE CANYON, NORTH, TO CONN VALLEY SCHOOLHOUSE.

Conn Valley school, 40 feet north of southeast corner, in grounds near fence; iron post stamped "319"-----	319.235
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MOUTH OF CHILES CREEK, NORTHWEST, TO BRIDGE 1 MILE NORTHEAST OF ST. HELENA; THENCE SOUTHWEST TO ST. HELENA.

St. Helena, 1.25 miles northeast of, in north wall, 25 feet east of west end of stone bridge over Napa Creek; bronze tablet stamped "221"-----	221.009
St. Helena, southwest corner of Main and Adam streets, in wall at north side of J. R. Kettlewell's hardware store, 1.7 feet above sidewalk, 1.5 feet from corner; bronze tablet stamped "255"-----	254.742

KNIGHTS LANDING QUADRANGLE.

ROUGH AND READY LANDING, SOUTHEAST ALONG RIVER ROAD, TO KNIGHTS LANDING STATION.

Derby Camp, 1.3 miles east of, north edge of river levee, opposite Chinese camp; iron post stamped "39 B"-----	39.432
Knights Landing, bridge over Sacramento River, top of south abutment, west wing wall, south end of; aluminum tablet stamped "41 B"-----	41.553
Knights Landing station, 30 feet east of track, at corner of road, opposite north side of station; iron post stamped "32 B"-----	31.825

KNIGHTS LANDING, SOUTH ALONG RIVER ROAD, TO GRAYS BEND.

Knights Landing, 4 miles southeast of, west side of road at foot of levee, south line of Mr. Roseberry's place; iron post stamped "30 B"-----	30.132
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GRAYS BEND, EAST DOWN RIVER ROAD, TO ELKHORN WEIR.

Knights Landing, 10.6 miles southeast of, 0.25 mile north of Doyle's house, 40 feet west of junction of river road and lane, north side of road; iron post stamped "29 B"-----	28.958
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DUNNIGAN QUADRANGLE.

HERSHEY, SOUTHEAST ALONG SOUTHERN PACIFIC RAILROAD, TO YOLO.

Hershey, 50 feet west of track, at road crossing 50 feet north of Colusa-Yolo County line; iron post stamped "137 B"-----	137.126
Dunnigan, 60 feet north of station, at edge of park fence; iron post stamped "67 B"-----	67.018

^a For additional elevations on Pope Valley quadrangle, see Capay and Rumsey 15' quadrangles (pp. 144 and 145).

PRIMARY LEVELING.

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	Feet.
Dunnigan, 3.2 miles south of, 50 feet east of milepost 101, 60 feet east of track, at road crossing; iron post stamped "45 B"-----	44.955
Zamora (Blacks station post-office), 0.65 mile north of, 0.2 mile south of milepost 98, east of track at corner of fence on right of way at public road crossing, sec. 17, T. 11 N., R. 1 E.; iron post stamped "46 B"-----	45.841
Ronda station, east of track at corner of right-of-way fence at road crossing, near milepost 94.7; iron post stamped "54 B"-----	54.183

COLLEGE CITY, SOUTHEAST AND SOUTH, TO NEAR DUNNIGAN.

John's school, 1.1 miles north of, at fence at southeast angle of cross-roads; iron post stamped "43 B"-----	43.017
Spanish ranch house, 1.6 miles north of, south side of county line, at entrance to ranch; iron post stamped "47 B"-----	47.024
Vombreyman's ranch, at fence line, northeast angle of road to north; iron post stamped "36 B"-----	35.702

SAM HINES RANCH, VIA HOWELL POINT, TO ROUGH AND READY LANDING.

Wilkins Slough school, at west end of fence, road in front of school; iron post stamped "32 B"-----	32.140
Wilkins Slough school, 2.3 miles south of, at road to J. M. Miller's ranch house; iron post stamped "34 B"-----	34.163
Howells Point, at entrance to landing, Yolo-Colusa County line; iron post stamped "37 B"-----	37.383
Howells Point, 1.8 miles south of, at gate leading to Ern Miller's ranch house; iron post stamped "31 B"-----	31.071
Rough and Ready Landing, at junction of canal and river, south side of canal, 40 feet west of large oil tank; iron post stamped "40 B"-----	40.633

KNIGHTS LANDING, WEST 4.0 MILES; THENCE NORTH TO ROUGH AND READY LANDING.

Blacks station post-office, 4.3 miles east of, at crossroads to Yolo and Grimes Landing, northeast corner angle of roads; iron post stamped "41 B"-----	41.177
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ZAMORA (BLACKS STATION POST-OFFICE), EAST 4.3 MILES.

Blacks station post-office, 2.5 miles east of, at corner of gate to barnyard of F. Schliemann's ranch house; iron post stamped "49 B"---	49.093
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DUNNIGAN, SOUTHWEST AND SOUTH ALONG COUNTY ROAD, TO NEAR BRIMLEY RANCH.

Brimley ranch, 1 mile north of, summit between Dunnigan and Fairview schoolhouse, east side of road; iron post stamped "333 B"---	333.203
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COLUSA, FRUTO 30', GRIMES, MAXWELL, SITES 30', TEHAMA, VINA, AND WILLOWS
QUADRANGLES.

COLUSA, GLENN, AND TEHAMA COUNTIES.

The elevations in the following list are based upon the precise-level line from Benicia north along the Southern Pacific Railroad to Oregon.

The leveling on Tehama and Vina quadrangles and part of that on Willows quadrangle was done in 1903 under Mr. R. B. Marshall, topographer, by Messrs. S. E. Blout and E. W. Glafcke, levelmen.

The remainder on Willows quadrangle was done in 1904 by Messrs. E. M. Fry and C. L. Nelson, levelmen, and that on remainder of Fruto 30' quadrangle was done in 1904 by Mr. H. Hartley, levelman.

The leveling on Colusa, Grimes, and part of Maxwell quadrangles was done in 1904 by Messrs. C. H. Semper and E. M. Fry, levelmen; that on remainder of Maxwell quadrangle in 1904 by Mr. Hartley. The leveling on remainder of Sites 30' quadrangle was done in 1904 by Messrs. Hartley and Fry.

MAXWELL QUADRANGLE.

WILLOWS, SOUTH ALONG SOUTHERN PACIFIC RAILROAD, TO WOODLAND.

	Feet.
Willows, 3 miles south of, east side of road at milepost 148, at right of way fence; iron post stamped "111 B"-----	110. 891
Logadale, at telegraph pole opposite milepost 145; iron post stamped "103 B"-----	102. 000
Norman, 600 feet north of brick warehouse, on west side of road; iron post stamped "91 B"-----	91. 325
Norman, 1.2 miles south of, 1,800 feet north of county line, east of road, at third telephone pole south of milepost 142; iron post stamped "90 B"-----	90. 330
Delevan, northwest corner of right of way fence, at forks of road, at milepost 139; iron post stamped "95 B"-----	95. 399
Maxwell, 2 miles north of, west of road, first telegraph pole south of milepost 136; iron post stamped "90 B"-----	89. 608
Maxwell, 150 feet west of station, northeast corner of lot, south margin of Main street, at base of flag pole; iron post stamped "93 B"-----	93. 332

POINT 3 MILES EAST OF WILLOWS, SOUTH AND WEST, TO NORMAN.

Willows, 4 miles south by 3 miles east of, at southwest corner of fence at forks of road; iron post stamped "97 B"-----	95. 553
Willows, 6.4 miles south by 3 miles east of, east side of road at south-east corner of fence; iron post stamped "86 B"-----	83. 884

NORMAN, EAST TO PRINCETON; THENCE NORTH TO GLENN.

Princeton, 3 miles west of, west of gate, 1 foot from fence at south side of road; iron post stamped "70 B"-----	70. 239
Princeton, 1 foot north of north wall of brick building, used as general store and post-office, 3 feet west of well, 10 feet west of Commercial street; iron post stamped "80 B"-----	80. 217
Princeton, 4 miles north of, 50 feet east of wagon bridge over canal, at fence corner, 30 feet southwest of crossroads; iron post stamped "86 B"-----	85. 983

THREE MILES EAST OF NORMAN, SOUTH AND WEST TO MAXWELL.

Glenn, Colusa County line, 60 feet east of fence, T, 18 N., between Rs. 2 and 3 W.; iron post stamped "71 B"-----	69. 217
Excelsior schoolhouse, 200 feet west of, on east side of road, at corner of schoolhouse; iron post stamped "62 B"-----	60. 431
Maxwell, 4 miles east of, south side of road at forks; iron post stamped "56 B"-----	54. 453

PRIMARY LEVELING.

149

EXCELSIOR SCHOOLHOUSE, EAST ACROSS COUNTRY, TO COMPTON LANDING; THENCE NORTH TO PRINCETON.

	Feet.
Compton Landing, 0.2 mile south of, corner of fence at west side of road; iron post stamped "67 B"-----	67.147
Princeton, in front wall of brick store building (property of P. P. Tapscott) 5 feet south of door, east side of Commercial street; aluminum tablet stamped "83 B"-----	82.947

COMPTON LANDING, SOUTH TO COLUSA.

Colusa, 5 miles north of, 150 feet southwest of Sever's ranch house, 25 feet east of forks of road; iron post stamped "60 B"-----	60.229
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FORKS OF ROADS 4 MILES WEST OF NORMAN, SOUTH 3 MILES; THENCE EAST 1 MILE.

Norman, 3 miles west by 3 miles south of, Lower Campbell ranch, northeast corner of bunk house, 400 feet northeast of water tank; iron post stamped "117 B"-----	117.070
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GRIMES QUADRANGLE.

COLUSA, SOUTHEAST, TO SYCAMORE.

Sycamore, at east margin of highway, opposite saloon, between locust trees; iron post stamped "48 B"-----	48.129
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FORKS OF ROAD 2.7 MILES SOUTH OF SYCAMORE, SOUTH AND WEST TO ARBUCKLE.

Grimes Landing, at northwest corner of Main and Second streets; iron post stamped "47 B"-----	47.089
Sam Hines' ranch, in northwest angle of roads; iron post stamped "32 B"-----	32.108
Hines (Sam), 2.6 miles west of, 145 feet west of levee, south of road; iron post stamped "26 B"-----	25.932
College City, 1.5 miles north and east of, 1,100 feet west of bridge over slough, at southeast angle of road to south; iron post stamped "36 B"-----	35.824

COLUSA (FRUTO 30') QUADRANGLE.

COLUSA JUNCTION, SOUTH ALONG SOUTHERN PACIFIC RAILROAD, TO ARBUCKLE.

Colusa Junction, 100 feet south of station, 300 feet north of railroad crossing, east of track; iron post stamped "79 B"-----	78.749
Williams, 2 miles north of, 60 feet west of track, north of road on line of right of way fence, at crossroads; iron post stamped "73 B"-----	73.338
Williams, 110 feet west of track, 125 feet northwest of station, south side of street; iron post stamped "79 B"-----	78.845
Williams, 4 miles south of, 250 feet south of milepost 121, fence corner at road crossing; iron post stamped "90 B"-----	89.605
Arbuckle, 2.4 miles north of, east of road, 100 feet west of track, at fence opposite milepost 117; iron post stamped "106 B"-----	106.394
Arbuckle, 130 feet west of, at base of 50-foot flagpole; iron post stamped "137 B"-----	136.683

COLUSA, WEST, TO COLUSA JUNCTION.

	Feet.
Colusa, 150 feet west of corner of Ninth and Market streets, 10 feet south of sidewalk, on south side of street, in city park; iron post stamped "58 B"-----	58.265
Colusa, north wall of Colusa County court-house, 15 feet west of main entrance; aluminum tablet stamped "60 B 1904"-----	60.375
Colusa, 3.5 miles west of, at south side of wagon road, 75 feet south-east of bridge over slough, 60 feet south of track; iron post stamped "51 B"-----	51.205

COLUSA JUNCTION, WEST, TO LURLINE.

Lurline station, 75 feet east of schoolhouse, 25 feet south of track, northwest corner of warehouse; iron post stamped "111 B"-----	111.023
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ONE MILE NORTH OF WILLIAMS, WEST, TO FRESHWATER SCHOOLHOUSE.

Freshwater schoolhouse, 50 feet northwest of, south side of county road, 100 feet west of well; iron post stamped "121 B"-----	120.953
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SYCAMORE, WEST, TO WILLIAMS.

Williams, 6.6 miles east of, at corner of fence west of high levee north of road; iron post stamped "39 B"-----	39.584
Williams, 3.4 miles east of, at southeast angle of crossroads, at line of fence; iron post stamped "56 B"-----	56.491

SYCAMORE, SOUTH AND WEST VIA COUNTY ROAD, TO BERLIN.

Dry Slough schoolhouse, 3 miles west of, at southeast angle of crossroads; iron post stamped "42 B"-----	42.125
Prize, 0.5 mile west of, south of road at road to north, 20 feet west of bridge; iron post stamped "51 B"-----	51.173

STORAL RANCH, SOUTHEAST TO CORTINA SCHOOLHOUSE; THENCE EAST TO BERLIN.

T. 15 N., R. 3 W., southeast corner sec. 32, 0.5 mile north by 0.5 mile east of Montgomery ranch house, corner of fence at east side of road, on township line; iron post stamped "167 B"-----	167.127
Cortina schoolhouse, 0.2 mile west of, southwest corner section 14, T. 14 N., R. 3 W., corner of fence; iron post stamped "211 B"-----	211.093

FORKS OF ROAD 1.2 MILES EAST OF CORTINA SCHOOLHOUSE, SOUTH TO COMMON CORNER
TS. 13 AND 14, RS. 2 AND 3.

Arbuckle, 4.5 miles west of, 30 feet south of corner of Ts. 13 and 14 N., Rs. 2 and 3 W., corner of fence; iron post stamped "284 B"-----	284.174
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SITES 30' QUADRANGLE.

CROSSROADS 5 MILES WEST OF WILLOWS, ALONG ROAD SOUTH, TO CROSSROADS 5 MILES
WEST OF NORMAN; THENCE TO NORMAN.

T. 19 N., R. 4 W., section 26, northwest corner of, on north and west side of road; iron post stamped "170 B"-----	170.026
T. 18 N., R. 4 W., northwest corner section 11, south and east of road; iron post stamped "168 B"-----	168.181
T. 18 N., R. 4 W., northwest corner section 24, 4 miles west of Norman, north and east side of road; iron post stamped "135 B"-----	135.149

PRIMARY LEVELING.

151

POINT 3 MILES SOUTH BY 3 MILES WEST OF NORMAN, SOUTHWEST TO GOLDEN GATE SCHOOLHOUSE; THENCE SOUTH TO LURLINE.

	Feet.
Miles station, 3 miles north of, Campbell's house, 50 feet northeast of, 40 feet east of blacksmith shop, northeast corner of yard fence, at south side of road; iron post stamped "157 B"-----	157. 041
Golden Gate schoolhouse, 1 mile south of, 400 feet south of Malloway ranch house, west side of road, 6 feet west of gate; iron post stamped "243 B"-----	243. 080
Mills station, 120 feet east of water tank, northeast corner of platform, 5 feet south of track; iron post stamped "146 B"-----	146. 157

FAIRVIEW STATION, SOUTH ALONG COUNTY ROAD, TO FRESHWATER.

Manor ranch, 0.2 mile southwest of ranch house, corner of fence at south side of county road; iron post stamped "157 B"-----	156. 997
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MANOR RANCH, SOUTH, TO STORAL RANCH.

Storal ranch house (West ranch), 600 feet northeast of, large gate, at west end of, north side of road; iron post stamped "183 B"-----	183. 028
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WILLOWS QUADRANGLE.

WILLOWS, NORTH ALONG RAILROAD, TO ORLAND.

Willows, 100 feet north of station, 75 feet west of track, north side of street, corner lot; iron post stamped "132 B"-----	130. 896
Willows, Glenn County court-house steps; aluminum tablet stamped "138 B"-----	137. 937
Willows, 700 feet north of station, 10 feet east of Southern Pacific track, 3 feet east of milepost 151 and section post 48-49, southwest corner brick warehouse; aluminum tablet stamped "134 B"-----	133. 969
Lyman, 0.2 mile south of, opposite milepost 154, east side of county road, alongside right-of-way fence; iron post stamped "138 B"---	137. 098
Germantown, 0.7 mile south of, west side of county road, 900 feet south of crossroads, opposite milepost 157; iron post stamped "159 B"-----	158. 226
Germantown, 2.5 miles north of, east side of county road, opposite milepost 160, at forks of road; iron post stamped "185 B"-----	184. 001
Greenwood, at crossroads, west of station, west side of county road, opposite milepost 163; iron post stamped "230 B"-----	228. 641
Orland station, 300 feet north of, 30 feet east of track, at road crossing; iron post stamped "256 B"-----	255. 084
Orland, northwest corner of Bank of Orland; aluminum tablet stamped "256 B"-----	255. 948

ORLAND, EASTERLY, TO ST. JOHNS.

Orland, 3 miles east of, 200 feet south of crossroads, east side of road at orchard; iron post stamped "217 B 37"-----	215. 007
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THREE MILES WEST OF ORLAND, SOUTH ALONG TOWNSHIP LINE, TO POINT 3 MILES EAST OF WILLOWS; THENCE TO WILLOWS.

Greenwood, 3 miles east of, northwest corner of fence at crossroads, 0.5 mile south of cemetery; iron post stamped "200 B 38"-----	199. 472
T. 21 N., R. 3 W., southeast corner section 24, west side of road, 0.25 mile west of large lone tree, in field; iron post stamped "171 B 39"-----	169. 318

	Feet.
T. 20 N., R. 2 W., southwest corner section 6, crossroads at Schlouse ranch house, at northeast fence corner; iron post stamped "152 B 40"-----	150. 183
T. 20 N., R. 2 W., east of county road, 370 feet south of Central canal; iron post stamped "135 B"-----	132. 616
Willows, 3.2 miles east of, crossroads, 100 feet north of ranch house, east side of road; iron post stamped "111 B"-----	109. 941

CHICO, WEST TO ST. JOHNS; THENCE SOUTH TO JACINTO; THENCE WEST TO TOWNSHIP LINE.

St. John, 300 feet south of Stony Creek, 40 feet northeast of intersection of roads, in southwest corner of school yard; iron post stamped "143 B"-----	142. 996
St. John, 2.4 miles south of, 1,200 feet southwest of white house, first turn in road to west, 12 feet northwest of fence corner; iron post stamped "134 B"-----	133. 963
St. John, 5.1 miles south of, 150 feet north of bridge, 30 feet northeast of intersection of county roads and private road, 600 feet west of frame house, 2 feet northwest of fence corner; iron post stamped "122 B"-----	122. 020
Jacinto, 0.1 mile north of, 500 feet north of red brick store, 20 feet south and 20 feet west of road, 6 feet west of signpost; iron post stamped "108 B"-----	107. 986

JACINTO, SOUTH, TO GLENN.

Sidds Landing, at southeast corner of warehouse, 50 feet west of river, and 50 feet east of road; iron post stamped "106 B"-----	105. 935
Glenn, 0.5 mile south of, 50 feet east of road, at front entrance to old schoolhouse, at south end of steps; iron post stamped "93 B"-----	92. 987

VINA (FRUTO 30') QUADRANGLE.

ST. JOHNS, NORTHWEST TO MCINTOSH RANCH; THENCE NORTH VIA SQUAW HILL, TO VINA.

Stony Creek station, 6 miles east of, 0.4 mile south of McIntosh's ranch house, intersection of private road with county road, 30 feet northwest of forks, 2 feet south of fence corner; iron post stamped "185 B"-----	184. 996
Squaw Hill Ferry, 250 feet west of west landing, in fence corner; iron post stamped "196 B"-----	195. 839

ORLAND, NORTH ALONG COUNTY ROAD, TO CORNING.

Orland, 2.6 miles north of, east side of road, 5 feet west of fence; iron post stamped "273 B"-----	271. 486
Orland, 4 miles north of, west side of road, 300 feet north of dry creek, at foot of electric pole, 1,233; iron post stamped "274 B"-----	273. 004
Orland, 6.6 miles north of, west side of road, 60 feet west of electric pole, 1,116; iron post stamped "286 B"-----	285. 040
Orland, 10 miles north of, east side of road, in Maywood Colony, at electric pole, 964; iron post stamped "271 B"-----	269. 972
Corning, 100 feet west of station, south side of street at northwest corner of warehouse; iron post stamped "273 B"-----	271. 410

PRIMARY LEVELING.

153

CORNING, EAST ALONG COUNTY ROAD, TO SQUALL HILL FERRY.

	Feet.
Corning, 3 miles east of, south side of road, at crossroads, 8 feet east of telephone pole; iron post stamped "222 B"-----	220.365

FROM CROSSROADS 3 MILES EAST OF CORNING, SOUTH ALONG COUNTY ROAD, TO CROSSROADS 3 MILES EAST OF ORLAND.*

Corning, 4 miles south by 3 miles east of, common corner secs. 5, 6, 7, and 8, T. 23 N., R. 2 W., at fence; iron post stamped "217 B"-----	216.028
Kirkwood, 2.5 miles southeast of, east side of road at fence corner; iron post stamped "215 B 35"-----	213.506
Malton, 2 miles east by 0.4 mile south of, 1 mile south of Jones ranch, west side of road at clump of fig trees; iron post stamped "220 B"-----	218.650

TEHAMA, SOUTH ALONG COUNTY ROAD, TO CROSSROADS 3 MILES EAST OF CORNING.

Tehama, 3.5 miles south of, 0.75 mile north of Thom Creek, east side of road, at foot of telegraph pole; iron post stamped "222 B"-----	220.661
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CORNING, NORTH ALONG COUNTY ROAD, TO CROSSROADS 7 MILES NORTH OF CORNING.

Corning, 3 miles northwest of, at crossroads, west side of road, 5 feet north of telephone pole; iron post stamped "303 B"-----	303.496
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FRUTO 30' QUADRANGLE.

WILLOWS, WEST ALONG COUNTY ROAD 5.5 MILES; THENCE NORTH TO POINT 4.5 MILES WEST OF ORLAND; THENCE TO ORLAND.

Willows, 5 miles west of, south side of road near crossroads, opposite schoolhouse; iron post stamped "190 B"-----	189.868
T. 20 N., R. 4 W., sec. 23, Feeny place, west side of road near barn; iron post stamped "190 B"-----	189.751
T. 20 N., R. 3 W., northwest corner sec. 1, south of road; iron post stamped "204 B"-----	203.917
T. 21 N., R. 4 W., northwest corner sec. 24, west of road; iron post stamped "251 B"-----	250.866
T. 21 N., R. 4 W., northwest corner sec. 1, 600 feet east of Butte ranch house, north side of road, near fence corner; iron post stamped "281 B"-----	280.869

TEHAMA QUADRANGLE.

RED BLUFF, SOUTH ALONG COUNTY ROAD, TO CROSSROADS 7 MILES NORTH OF CORNING.*

Tehama, 5.5 miles west of, west side of road, Red Bluff at crossroads, 5 feet north of telephone pole; iron post stamped "308 B"-----	307.463
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RED BLUFF, SOUTH ALONG COUNTY ROAD, TO CROSSROADS 7 MILES NORTH OF CORNING.*

Red Bluff, 6.5 miles south of, west side of road, 3 feet south of telephone pole; iron post stamped "311 B"-----	310.497
Red Bluff, 10.5 miles south of, west side of road, 4 feet north of telephone pole; iron post stamped "304 B"-----	303.664

*The error distributed in this line is excessive.

TEHAMA, NORTH THROUGH CONE RANCH, TO RED BLUFF.

	Feet.
Tehama, 4 miles northeast of, 50 feet south of draw in small bunch of oaks, east side of county road, through Cone ranch; iron post stamped "233 B"-----	233.489
Antelope Creek, 40 feet north of bridge, east side of road; iron post stamped "234 B"-----	234.067
Cone estate, 0.25 mile north of adobe ranch house, west side of road, south side of Antelope Creek at bridge; iron post stamped "246 B"-----	246.129
Cone estate, Antelope ranch headquarters, beside walk in front of residence, east side of road; iron post stamped "271 B"-----	270.764
MILL CREEK HIGHWAY BRIDGE, EAST 4 MILES UP MILL CREEK; THENCE NORTH TO DAY CREEK; THENCE WEST TO ROAD FORK 1 MILE NORTH OF ANTELOPE RANCH.	
T. 26 N., R. 1 W., sec. 31, southeast corner, north of Mill Creek, 10 feet north of road; iron post stamped "471 B"-----	471.259

WILD CAT GULCH, EASTWARD, TO T. 26 N., R. 1 W.

Wild Cat Creek, 2 miles east of, north side of road, in highest point of lava boulder; aluminum tablet stamped "1040 B"-----	1,040.359
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DRY CREEK, NORTHWEST AND WESTWARD ALONG PRIVATE ROADS AT BASE OF FOOTHILLS, TO RED BLUFF.

Dry Creek sheep camp, 4 miles north of, 350 feet west of west end of stone fence, 4 feet east of gatepost; iron post stamped "301 B"---	300.865
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POINT 6 MILES EAST OF RED BLUFF, EAST ALONG THE RED BLUFF AND LYONSVILLE ROAD, TO MUD SPRINGS.

Red Bluff, 6 miles east of, at forks of road to Tuscan Springs, near signpost; iron post stamped "307 B 1903"-----	306.629
Mud Springs, 0.25 mile west of, 15 feet south of road, in sec. 6, T. 27 N., R. 1 W., in lava boulder, 6 by 4 by 2 feet; aluminum tablet stamped "1061 B"-----	1,061.406

MILL CREEK, SOUTH TO TOOMES CREEK; THENCE SOUTHWEST TO MILEPOST 207.

Lone Pine camp, Toomes Creek sheep camp, 200 feet west of ranch house, 4 feet east of telephone pole; iron post stamped "358 B"--	358.180
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IRON MOUNTAIN SPECIAL AND REDDING QUADRANGLES.

SHASTA COUNTY.

The elevations in the following list are based on an aluminum tablet set in first angle of wall on north side of east entrance to the court-house in Redding, about 3 feet above ground. The height of this bench mark was accepted as 589.658 feet, being determined by the precise-level line run by Mr. C. H. Semper in 1902, between Benicia, Cal., and Portland, Oreg. For additional elevations refer to precise leveling (p. 26).

The leveling on Redding quadrangle was done mostly in 1900 by Mr. L. A. Whereat, levelman, under the direction of Messrs. R. H.

McKee and A. B. Searle, topographers. The leveling on the Iron Mountain Special quadrangle is part of that on the Redding quadrangle, and was done by Mr. A. B. Searle in 1903. The latest work is a line from Redding via Shasta to Girvan, run in 1905 by Mr. G. C. Jacobs.

The standard bench marks set in 1900 are stamped with the letter "R" in addition to figures of elevation, mostly 2 feet too great; those set in 1903 and 1905 are stamped "B" with correct figures.

REDDING QUADRANGLE.

REDDING, VIA FURNACEVILLE, TO WARD'S RANCH ON REED'S TOLL ROAD.

	Feet.
Loomis Corners, west side of Leighton's house, 2 feet south of north-east corner of fence; iron post stamped "550 R"-----	547.964
Rocky Plains, near center of, 2 miles southwest of Ben Jenkins's house, 15 feet south of road; iron post stamped "1109 R"-----	1, 106.749
Ward's field, 2 feet east and 8 feet south of fence around, south side of Reed's (Redding-Furnaceville) toll road and 12 feet west of fork of private road leading via Eller's to Oak Run road; iron post stamped "1279 R"-----	1, 276.685

ENTERPRISE, VIA PALOCEDRO AND BELLAVISTA, TO FRAZIER CORNERS.

Pacheco schoolhouse, 20 feet east of road, 2 feet south of southwest corner; iron post stamped "449 R"-----	446.953
Bellavista, 15 feet north of county road as traveled, 2 feet southwest of southeast corner of fence around superintendent's house; iron post stamped "537 R"-----	535.036

PALOCEDRO, VIA MILLVILLE AND PAWNEE, TO WARD'S RANCH AND CLOVER CREEK FALLS ON FURNACEVILLE ROAD.

Millville schoolhouse, 2 feet south of southwest corner of; iron post stamped "513 R"-----	510.942
Frank Joseph's house, 540 feet northeast of, 6 feet southeast of tamarack road, 1.5 feet from northwest fence corner of the Tom Webb place on the continuation of division line between the Webb and Joseph farms; iron post stamped "977 R"-----	974.996

MILLVILLE, VIA SHINGLETOWN CUTOFF ROAD, TO BEAR CREEK CROSSING.

George Darr's house, 190 feet east of gate, 2 feet north of fence, south side of road, on top of grade going down to Bear Creek; iron post stamped "806 R"-----	803.633
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REDDING, VIA SHASTA, TO KESWICK.

Shasta, 50 feet northwest of west corner of Empire Hotel, 4 feet south of corner of corral, on northeast side of the main street, and on northwest side of street to Keswick; iron post stamped "1049 R"-----	1, 046.886
Keswick schoolhouse, 6 feet south of first angle of west face; iron post stamped "778 R"-----	775.897

SHASTA, SOUTH ALONG ROAD TO CENTERVILLE (LARKIN); THENCE EAST TO GIRVAN.

	Feet.
Shasta, 2.7 miles south of, on ledge of rock facing south, west side of road, 150 feet south of old shed; aluminum tablet stamped "930 B 05"-----	929.959
Centerville (Larkin), west side of road, opposite Centerville store; iron post stamped "876 B"-----	876.459
Centerville, 2.9 miles east of, 80 feet south of road, 300 feet west of house at junction of roads from Redding and Girvan to Centerville, on ledge of sandstone; aluminum tablet stamped "562 B 05"-----	562.338

FRAZIERS CORNERS, VIA BEAR VALLEY, COPPER CITY, MADISON'S AND KELLEY'S RANCH, TO BAGLEY FLAT (SINGLE SPUR LINE).

Houston ranch, 1.6 miles northwest of, on Stillwater road 15 feet south of fork with and 5 feet east of Copper City road, 500 feet south of forks with road to Bass's; iron post stamped "710 R"----	707.791
Bear Valley, 0.15 mile southwest of stage station, 180 feet north-east of junction with Bellavista road, 18 feet southeast of road, 2 feet northwest of fence, on top of hill; iron post stamped "945 R"-----	942.672
Copper City, 25 feet south of schoolhouse, at southeast corner of lot as at present defined by fence; iron post stamped "806 R"-----	803.877
Squaw Creek, near east side line of T. 34 N., R. 2 W., 300 feet above first crossing, 1.87 miles north of Madison's house, 6 feet east of trail; iron post stamped "1047 R"-----	1,044.357
T. 35 N., R. 2 W., 1.39 miles north of Kelly's house, near east range line, 10 feet west of trail on saddle; iron post stamped "1536 R"---	1,533.719
Bagley Flat, 135 feet southwest of cabin, 85 feet southwest of head of spring; iron post stamped "2730 R"-----	2,727.880

POINT ON SOUTHERN PACIFIC RAILROAD, UP MIDDLE SALT CREEK.

T. 36 N., R. 4 W., 3.5 feet west of southeast corner of sec. 30, on line between Ts. 35 and 36 N., R. 4 W., Mount Diablo meridian; iron post stamped "1182 R"-----	1,180.038
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BENCH MARKS BASED UPON M'CLOUD RIVER DITCH LEVELS, CORRECTED FROM DATA FURNISHED BY J. R. ROGERS, ENGINEER IN CHARGE.

T. 34 N., R. 4 W., northwest corner of sec. 23, 5 feet southeast of northwest corner of "McCloud River," U. S. Fish Reservation, 30 feet west of county road; iron post stamped "856 R"-----	853.786
T. 36 N., R. 3 W., south edge of sec. 31, on west bank of McCloud River, near head of Rogers ditch line, and 100 feet west of ditch station 71+50, 146 feet west of 10-inch forked live oak tree; iron post stamped "1060 R"-----	1,057.616

IRON MOUNTAIN SPECIAL (REDDING 30') QUADRANGLE.

KENNETH, WEST ALONG ROAD TO BALAKLALA; THENCE ALONG TRAIL, VIA SPREAD EAGLE MINE AND SADDLE OF COPLEY RIDGE (0.5 MILE EAST OF SUGARLOAF MINE), TO COPLEY.

Balaklala Mining Company's office, 20 feet north of north end of, 20 feet south of road, at base of stone wall; iron post stamped "2286 B"-----	2,285.922
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	Feet.
Spread Eagle mine, 0.5 mile northeast of, 5 feet west of trail at point of ridge; iron post stamped "2757 B"-----	2, 756.924
Forks of Copley-Sugar Loaf and Minnesota-Sheep Springs trail, 10 feet east of, in saddle; iron post stamped "2560 B"-----	2, 560.138

BORALMA, ALONG ROAD, TO TUNNEL NO. 11 OF TRINITY COPPER COMPANY.

Tunnel No. 11, Trinity Copper Company, 2 feet southwest of mouth; iron post stamped "1636 B"-----	1, 636.086
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BIG BAR, EUREKA, HOOPA, KORBEL, AND WEAVERVILLE QUADRANGLES.

HUMBOLDT, SHASTA, AND TRINITY COUNTIES.

The elevations in the following list are based on an aluminum tablet set about 3 feet above ground in first angle of wall on north side of east entrance to the court-house in Readding, accepted as being 589.658 feet above mean tide. In October, 1905, levels were run west and north over road and trail to vicinity of China Flat, work being abandoned in January, 1906. The leveling was done by Mr. George C. Jacobs, levelman, with a prism level and two rodmen with self-reading yard rods. In August, 1906, work was continued in the same manner with prism level by Mr. L. F. Biggs, levelman, northward to Hoopa Valley and westward to Eureka. At this point the Coast and Geodetic Survey bench mark on the warehouse wharf was sought but was not recovered. City bench marks Nos. 2 and 3 were checked on, their city value being 14.925 and 35.113 feet, respectively. Their datum plane as established by the United States Army engineers was accepted as 2.480 feet lower than mean tide, making their accepted elevations 12.445 and 32.633 feet, respectively.

The error of closure was found to be excessive, and although the elevations in this list are adjusted they must be regarded as preliminary only.

The lines of levels run by Mr. Jacobs and Mr. Biggs on the Shasta-Eureka line were checked roughly by second running by flying levels in opposite direction by Mr. Biggs.

WEAVERVILLE QUADRANGLE.

SHASTA, NORTHWEST ALONG ROAD VIA STELLA AND LOWDEN, TO WEAVERVILLE.

	Feet.
Shasta, 2 miles northwest of, 30 feet northeast of Camden turnpike at Shasta divide, and 75 feet east of telephone pole; iron post stamped "1428 B 1905"-----	1, 428.345
Stella post-office; center of bridge over Whiskey Creek-----	1, 065.6
Stella, south side of road, opposite hotel; iron post stamped "1091 B 1905"-----	1, 091.031
Oak Bottom, 0.2 mile northwest of, northeast side of Camden turnpike, 6 telephone poles east of Shasta 8 milepost, on ledge of rock facing east; aluminum tablet stamped "1191 B 1905"-----	1, 190.916

	Feet.
Tower House, 0.7 mile southeast of, north side of Camden turnpike, 630 feet northwest of Tower House 1 milepost; aluminum tablet stamped "1318 B 1905"-----	1,317.641
Tower House, 3.5 miles west of, south side of Shasta and Weaverville turnpike, on large boulder opposite Endicott ranch house; aluminum tablet stamped "1750 B 1905"-----	1,750.025
Buckhorn station, 4.4 miles east of, south side of road and east end of cut at summit; iron post stamped "3252 B 1905"-----	3,260.917
Buckhorn, 2.4 miles east of station, east side of road, at culvert, on large boulder; aluminum tablet stamped "2754 B 1905"-----	2,763.541
Buckhorn, 1.2 miles northwest of station, north side of road, on large boulder; aluminum tablet stamped "2374 B 1905"-----	2,382.974
Lowden, 1.5 miles southeast of, north side of road, in rock; aluminum tablet stamped "2093 B 1905"-----	2,102.466
Lowden, west side of road in front of hotel; iron post stamped "1754 B 1905"-----	1,763.500
Lowden, 3.2 miles northwest of, north side of road, 320 feet southeast of Weaverville milepost 6, on rock; aluminum tablet stamped "2710 B 1905"-----	2,722.304
Weaverville, 2.9 miles south of, 375 feet north of junction of roads from Lowden and Douglas, east side of road on ledge of rock; aluminum tablet stamped "1816 B 1905"-----	1,828.647
Weaverville, southeast corner of court-house, in pavement; aluminum tablet stamped "2034 B 1905"-----	2,046.869

WEAVERVILLE, ALONG ROAD VIA JUNCTION, TO HELENA.

Weaverville, 2.8 miles west of, 0.5 mile east of summit, north side of road, on rock; aluminum tablet stamped "2738 B 1905"-----	2,750.674
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BIG BAR QUADRANGLE.

ALONG HIGHWAY, VIA JUNCTION CITY, TO HELENA.

Junction City, 3.9 miles east of, 0.9 mile west of La Grange mine, southwest side of road, in top of stone monument, Mount Diablo meridian; copper plate stamped "2218 B"-----	2,230.907
Junction City, northwest side of road, 200 feet west of gravel bluff, 200 feet south of church, on large white boulder; aluminum tablet stamped "1478 B 1905"-----	1,491.026
Junction City, 2.7 miles northwest of, north side of road, 300 feet west of where North Mountain Power Company's pipe line crosses road, on ledge of rock; aluminum tablet stamped "1747 B 1905"-----	1,760.070
Helena, 2.3 miles east of, southeast side of road, northwest bank of Trinity River, on large boulder; aluminum tablet stamped "1410 B 1905"-----	1,422.594
Helena post-office, northeast side of road, 4 feet from south corner of brick store; iron post stamped "1391 B 1905"-----	1,403.506

HELENA, ALONG TRAIL DOWN NORTH SIDE OF TRINITY RIVER, TO LUCCOCKS BAR; THENCE ON SOUTH SIDE TO DON JUAN POINT; THENCE ON NORTH SIDE TO CEDAR FLAT.

Helena, 3 miles west of, south side of trail, east side of brook, top of rock in Cut Throat Gulch; aluminum tablet stamped "1637 B 1905"-----	1,649.862
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	Feet.
Big Bar, 3.5 miles east of, north side of Big Flat, 80 feet north of trail, 20 feet northwest of power pole, on rock; aluminum tablet stamped "1304 B 1905"-----	1, 313. 460
Big Bar, 0.7 mile east of, opposite Big Bar Hotel, 450 feet north of suspension bridge, 30 feet north of trail, east side of gulch, 250 feet east of house, top of rock; aluminum tablet stamped "1238 B 1905"-----	1, 247. 585
Big Bar, 2.1 miles west of, north side of trail, at base of rock cliff facing southeast; aluminum tablet stamped "1398 B 1905"-----	1, 408. 076
Taylor Flat, 1.3 miles east of, north side of trail, 850 feet east of rock cliff, top of bowlder; aluminum tablet stamped "1229 B 1905"-----	1, 239. 125
Taylor Flat, 1.6 miles west of, 1,500 feet west of Canadian Bar, 80 feet south of trail, on rock; aluminum tablet stamped "1263 B 1905"-----	1, 272. 801
Cedar Flat, 5.4 miles east of, north side of trail, 625 feet east of Vance Creek, on rock; aluminum tablet stamped "1183 B 1905"-----	1, 193. 425
Cedar Flat, 1.9 miles east of, 675 feet west of suspension bridge over Trinity River, top of rock; aluminum tablet stamped "1003 B 1905"-----	1, 002. 262
Cedar Flat, 1.3 miles west of, 400 feet west of landslide, 40 feet north of trail, on rock; aluminum tablet stamped "1240 B 1905"-----	1, 249. 460

KORBEL QUADRANGLE.

SOUTH BANK, TO HAWKINS BAR; THENCE VIA CAMPBELLS BRIDGE, TO CHINA FLAT.

Burnt ranch, 500 feet west of house, 250 feet south of cemetery, 300 feet southeast of trail, on large bowlder; aluminum tablet stamped "1591 B 1905"-----	1, 601. 622
Gray, 175 feet north of trail, 500 feet northwest of house, on large bowlder; aluminum tablet stamped "777 B 1905"-----	787. 516
Hawkins Bar, 175 feet northwest of barn, 15 feet north of trail, on rock; aluminum tablet stamped "859 B 1905"-----	869. 491
Donahue ranch house, 2.7 miles southeast of, 60 feet west of trail, edge of river, 100 feet west of creek, top of rock; aluminum tablet stamped "519 B 1905"-----	528. 898
Donahue ranch house, 0.6 mile northwest of, 25 feet northwest of trail, 50 feet northwest of log cabin, at junction of South Fork and Trinity River, on rock; aluminum tablet stamped "543 B 1905"-----	553. 385
China Flat, 2.4 miles south of, west side of road, top of rock; aluminum tablet stamped "646 B 1906"-----	645. 195
China Flat, 160 feet north of hotel, 70 feet northeast of road to Hoopa, top of rock; aluminum tablet stamped "451 B 1906"-----	461. 149
China Flat, 2.8 miles north of, south side of road, first summit, large rock; aluminum tablet stamped "BB 1906 20"-----	644. 210

CHINA FLAT, ALONG ROAD VIA ACORN, TO KORBEL.

China Flat, 2.8 miles west of, 50 feet east of road, 25 feet south of Little Brannen Creek, 200 feet northeast of Koby ranch house, top of rock; aluminum tablet stamped "1459 B 1906"-----	1, 469. 422
Haas ranch house, 1.5 miles east of, 15 feet south of road at summit, top of rock; aluminum tablet stamped "3109 B 1906"-----	3, 118. 616
Haas ranch house, 225 feet northeast of, 35 feet northwest of road, on rock; aluminum tablet stamped "2352 B 1906"-----	2, 362. 617

	Feet.
Haas ranch house, 3 miles southwest of, 150 feet west of Redwood summit, south side road, in slate; aluminum tablet stamped "BB 3701 1906-13"-----	3, 714. 927
Redwood summit, 3 miles southwest of, 2.2 miles east of Berry's ranch house, west edge of road; aluminum tablet stamped "2517 B 1906"-----	2, 530. 941
Berry's ranch house, 100 feet southeast of, west face of rock; aluminum tablet stamped "B 1906"-----	1, 037. 563
Berry's ranch house, 3.4 miles northwest of, at junction of road from Baer ranch and China Flat, 4 feet south of telephone pole, on rock; aluminum tablet-----	2, 423. 727
Solano, 0.6 mile east of, 225 feet north of summit, 5 feet east of road, on rock; aluminum tablet stamped "B 1906"-----	3, 079. 729
Solano, 1.5 miles west of, 20 feet northeast of road, on ledge of sandstone; aluminum tablet stamped "B 1906"-----	2, 483. 452
Solano, 4.1 miles southwest of, 30 feet northwest of road, 1,500 feet southwest of mile tree 27, on rock; aluminum tablet stamped "1949 B 1906"-----	1, 962. 59
Korbel, 100 feet south of station, west side of large stone ledge; aluminum tablet stamped "BB 15 1906 1902"-----	115. 67

EUREKA QUADRANGLE.

KORBEL, ALONG ARCATA AND MAD RIVER RAILROAD, TO ARCATA.

Blue Lake station, in front of; top of rail-----	87. 8
Korbel, 1.7 miles southwest of, 0.6 mile west of Blue Lake, north side of railroad, large boulder; aluminum tablet stamped "BB 16 1906 72"-----	85. 72
Korbel, 6.2 miles west of, 3.6 miles east of Arcata, 300 feet south of Webster ranch house, south side of track, large boulder; aluminum tablet stamped "33.17 1906 58"-----	72. 20
Arcata, southeast corner of Eighth and H streets, northwest corner of brick building 25 by 100 feet; aluminum tablet stamped "BB 18 1906 27"-----	27. 10

ARCATA, ALONG EUREKA AND OREGON RAILROAD, TO EUREKA.

Bayside station, in front of; top of east rail-----	7. 793
Northeast corner of Pacific Steamship Company's warehouse; nail in floor-----	8. 273
Eureka, at intersection of Third and E streets, city bench mark No. 2-----	12. 445
Eureka City Hall, east approach to, north side of steps, in top of granite post; aluminum tablet stamped "BB 1906-19 31"-----	30. 934
Eureka, at intersection of Third and H streets, city bench mark No. 3-----	32. 633
Eureka, north approach to court-house, west side of steps, granite post; aluminum tablet stamped "BB 1906-20-44"-----	44. 059

HOOPA QUADRANGLE.

NEAR CHINA FLAT, ALONG ROAD, TO HOOPA.

China Flat, 6.3 miles north of, west edge of road, country rock; aluminum tablet stamped "BB 21, 1906"-----	1, 354. 915
Hoopa, 2.4 miles south of, 1,300 feet south of mile tree 63, 1,700 feet north of bridge, west edge of road, boulder; aluminum tablet stamped "BB 22 1906"-----	386. 042

PRIMARY LEVELING.

161

	Feet.
Hoopa, 1,000 feet north of Bigard's store, right edge of steps to United States Indian agent's office; aluminum tablet stamped "BB 352 23 1906"-----	351. 270

HOOPA, NORTH ALONG ROAD AND TRAIL 7.5 MILES (SINGLE SPUR LINE).

Hoopa, 3.2 miles north of, 150 feet south of Sockish Creek, west edge of road, country rock; aluminum tablet stamped "BB 24 1906"---	308. 482
Hoopa, 7.5 miles north of, west edge of trail, slate rock; aluminum tablet stamped "BB 25 1906"-----	1, 006. 208

HOOPA, SOUTHWEST ALONG TRAIL AND ROAD, TO FORKS OF ROAD 3.4 MILES NORTHWEST OF BERRY RANCH HOUSE.

Hoopa, 3.8 miles west of, 20 feet west of Fourmile Creek, large boulder; aluminum tablet stamped "B 1716 1906"-----	1, 715. 199
Hoopa, 6 miles west of, 10 feet south of trail, country boulder; aluminum tablet stamped "B 27 2899 1906"-----	2, 900. 323
Baer's ranch, 4.5 miles east of, north edge of trail, highest point, country rock; aluminum tablet stamped "B 28 1906 3495"-----	3, 494. 856

KORBEL QUADRANGLE.

AT BAERS RANCH.

Baer's ranch, 0.8 mile east of, 20 feet south of trail, very large boulder known as "14-mile rock;" aluminum tablet stamped "B 29 1359 1906"-----	1, 358. 118
Baer's ranch house, 1,000 feet southwest of, southwest corner of bridge, top of pier; aluminum tablet stamped "B 30 1906 732"-----	731. 773

PUBLICATIONS OF THE UNITED STATES GEOLOGICAL SURVEY.

The publications of the United States Geological Survey consist of (1) Annual Reports, (2) Monographs, (3) Professional Papers, (4) Bulletins, (5) Mineral Resources, (6) Water-Supply and Irrigation Papers, (7) Topographic Atlas of United States—folios and separate sheets thereof, (8) Geologic Atlas of United States—folios thereof. The classes numbered 2, 7, and 8 are sold at cost of publication; the others are distributed free. A circular giving complete lists can be had on application.

Most of the above publications can be obtained or consulted in the following ways:

1. A limited number are delivered to the Director of the Survey, from whom they can be obtained, free of charge (except classes 2, 7, and 8), on application.

2. A certain number are delivered to Senators and Representatives in Congress for distribution.

3. Other copies are deposited with the Superintendent of Documents, Washington, D. C., from whom they can be had at prices slightly above cost.

4. Copies of all Government publications are furnished to the principal public libraries in the large cities throughout the United States, where they can be consulted by those interested.

BULLETINS CONTAINING ELEVATIONS.

- 72. Altitudes between Lake Superior and Rocky Mountains, by Warren Upham. 1891. 229 pp.
- 169. Altitudes in Alaska, by Henry Gannett. 1900. 13 pp.
- 175. Triangulation and spirit leveling in Indian Territory, by C. H. Fitch. 1900. 141 pp., 1 pl.
- 185. Results of spirit leveling, fiscal year 1900–1901, by H. M. Wilson, J. H. Renshaw, E. M. Douglas, and R. U. Goode. 1901. 219 pp.
- 274. A dictionary of altitudes in the United States (fourth edition), compiled by Henry Gannett. 1906. 1,072 pp.
- 281. Results of spirit leveling in the State of New York for the years 1896 to 1905, inclusive, by S. S. Gannett and D. H. Baldwin. 1906. 112 pp.
- 288. Results of spirit leveling in Pennsylvania for the years 1899 to 1905, inclusive, by S. S. Gannett and D. H. Baldwin. 1906. 62 pp.

Results of spirit leveling by the United States Geological Survey also appear in the appendices to the 18th, 19th, 20th, and 21st annual reports of the Director.

Address communications to the Director.

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BULLETIN 343

ENDERS FOR COAL BRIQUETS

INVESTIGATIONS MADE AT THE
FUEL-TESTING PLANT
ST. LOUIS, MO.

BY

JAMES E. MILLS



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BINDERS FOR COAL BRIQUETS:

INVESTIGATIONS MADE AT THE FUEL-TESTING PLANT, ST. LOUIS, MO.^a

By JAMES E. MILLS.

INTRODUCTION.

THE COMMERCIAL PROBLEM.

Coal, in the process of mining, transportation, and handling and on exposure to the weather, is subject to more or less disintegration. This disintegrated coal is usually called "slack" and amounts often to a considerable percentage of the lump coal produced in the mines. If this slack coal is wasted the loss so occasioned ranges from 5 to 50 per cent, or even more, of the total coal mined. It is therefore clear that the utilization of this waste slack coal becomes a serious economic consideration.

When the coal is suitable for the production of coke, the utilization of the slack presents no difficulty, as it is in demand for that purpose. If the coal does not produce good coke, but cakes rather readily, the slack can be used for boiler purposes, as it fuses together more or less quickly, and burns on the furnace grate without great loss. Coal that cakes less readily can be burned on grates of special construction. When so used it is more troublesome to handle, and the waste is greater than when lump coal is used. Consequently the price of much of the slack coal for fuel purposes ranges considerably lower than that of the lump coal from the same mine.

The full value of this slack coal as fuel can be realized by first forming the coal into a coherent mass or briquet, such briquets, when of good quality, being equal to or of greater value than the original

^a The writer undertook the work herein reported, in 1905, at the fuel-testing plant of the United States Geological Survey, under the direction of Dr. Joseph Hyde Pratt, of the University of North Carolina, to whom he is greatly indebted for advice and suggestions, given not alone at the beginning but throughout the progress of the work. Acknowledgment is also due for suggestions given by Mr. A. A. Steel, of the University of Arkansas, and for the assistance of many individuals and corporations who have answered inquiries and furnished samples as desired. In compiling this report and in laboratory work free use has been made of all available information thus acquired.

lump coal from which the slack was derived. The object of the investigations herein reported was to determine as far as possible to what extent the manufacture of briquets from slack coal may succeed commercially under the conditions existing in the United States.

The problem of briquetting is not always that of how to make the best possible briquet, for the slack at hand may be of inferior quality and the best possible binding material may be too expensive for the conditions prevailing in that particular locality. The problem is always to produce at a profit a briquet of satisfactory grade for the use intended. This problem will be made clearer by a brief summary of the available binders, followed by a preliminary discussion of the characteristics of a good briquet.

THE KIND OF BINDER.

Definite answer to the question "What is the best binder to use in making briquets?" depends, as repeatedly emphasized in this paper, on the locality, on the character of the coal, and on the purpose for which the briquets are intended. For purposes of a brief comparison consideration is given to the binders available for a coal which is fairly easy to briquet and which cakes rather readily. A few coals will briquet with somewhat less and others require greater percentages of binder, but an endeavor has been made in the following summary to strike a reasonable average.

The experiments herein reported show that, in general, for plants situated where it can be obtained, the cheapest binder will prove to be the heavy residuum from petroleum, often known to the trade as asphalt. Four per cent of this binder being sufficient, its cost ranges from 45 to 60 cents per ton of briquets produced. This binder is particularly available in California, Texas, and adjacent territory.

Second in order of importance comes water-gas tar pitch. Five to six per cent usually proving sufficient, the cost of this binder ranges from 50 to 60 cents per ton of briquets produced. As water-gas pitch is also derived from petroleum, it will be available more particularly in oil-producing regions.

Third in order of importance is coal-tar pitch. Being derived from coal, this binder is very widely available. From 6.5 to 8 per cent will usually be required, and the cost ranges from 65 to 90 cents per ton of briquets produced.

Of local importance, where the price permits, are natural asphalts and tars derived from wood distillation. The price of each of these binders varies greatly with the locality, but there are doubtless places where they could compete with the binders above mentioned. Wax tailings could be used with an easily caking coal.

Pitch made from producer-gas tar is not yet on the market, but it will produce excellent briquets, with a lower percentage of binder

than other coal-tar pitches. It will doubtless be available in the future.

Briquets excellent in all respects except that they are not waterproof can be made by using 1 per cent of starch as a binder, the cost of which is 20 cents per ton of briquets produced. Extra care is necessary in drying and handling these briquets, and this adds to their cost.

The waste sulphite liquor from paper mills also produces excellent briquets except that they are not waterproof. At present it is a troublesome waste product dissolved in much water. Its utilization for this purpose will bear further investigation.

Of inorganic binders, magnesia might be utilized, as its probable cost would not exceed 22 to 30 cents per ton of briquets produced. Other inorganic binders, while available as regards price, would not make first-class briquets.

The briquetting of lignite coal offers a peculiarly difficult problem. If the lignite cakes in the fire, asphaltic residues from petroleum or water-gas tar pitch may be used as binder, larger percentages being required than for ordinary coals. The most promising binders for lignites that do not cake are starch, sulphite liquor, and magnesia. Lignites may be briquetted without binder if they are to be burned on grates specially constructed to overcome the tendency to fall to pieces in the fire.

Attention is called to the suggested method of deciding as to the value of coal-tar pitch for briquetting purposes. The method is likewise applicable to asphalts and petroleum residues generally: (1) The pitch or tar is distilled and all oils coming off below 270° C. are rejected as being of no value; (2) the flowing point of the portion to be used in briquetting is determined (this should generally not be less than 70° C.); (3) the pitch is extracted with carbon disulphide. The smaller the amount of residual carbon the more satisfactory is the pitch. The less readily the coal cakes the higher must be the flowing point of the pitch. If a pitch cracker is used, the pitch to work successfully on a hot summer's day must have a flowing point above 120° C. In the winter pitch with a flowing point of 100° C. may be used. All softer pitches and asphalts have to be melted and mixed in liquid form with the coal.

A pitch with a very high softening point, above 150° C., should be either thinned or superheated in the mixer. The efficient use of a binder depends very largely on the proper regulation of the conditions in the mixer. The presence of low-volatile compounds in the pitch to be used as a binder increases the smoke in burning; and also increases the tendency of the briquet to soften and crack open in advance of combustion, owing to the volatilization and escape of these compounds.

The main problem in briquetting is to find a suitable binding material at sufficiently low cost. When the difference in price between the slack coal and the first-class lump coal is \$1, the cost of briquetting should not exceed this amount. Of this the binder must cost less than 60 cents per ton, as the cost of manufacture averages about 40 cents. To leave out of consideration the possible advantages in the use of briquetted coal over run-of-mine coal, due to the greater efficiency and smokelessness of briquets, it will probably not be necessary to pay any attention to binding materials costing \$1.25 or more per ton of briquets produced.

CHARACTERISTICS OF GOOD BRIQUETS.

COHERENCE.

The briquet should be sufficiently coherent. In France briquets are tested for coherence as follows:^a

One hundred and ten pounds of briquets are divided into 100 pieces of 1.1 pounds each, which are placed in a cylinder 36.22 inches in diameter and 39.57 inches in length. This cylinder is divided into three compartments by diametrical partitions and revolves at a speed of 25 revolutions per minute. After being charged, it is revolved for two minutes, and the contents are thereupon sifted upon a screen perforated with holes 1.42 inches square. The proportion which does not pass through this screen indicates the degree of cohesive force, which, in the case of the French Admiralty tests, should reach 52 per cent, or if the fuel be intended for torpedo boat use, 58 per cent.

Briquets of any desired degree of coherence may be made by varying the amount of binding material used in the briquet and by varying the pressure. An increase of either the binder or the pressure, of course, represents an added cost in manufacture. Experiments made by M. Wéry, of Paris,^b with a Biétreix machine may be taken as illustrative:

Effect on coherence of varying pressure and amount of binder.

Pressure in kilo- grams per square cen- timeter.	Pressure in pounds per square inch.	Per cent of pitch used.	Per cent of cohesion obtained.
130	1,844	6	25
190	2,695	6	46
270	3,831	6	61
130	1,844	7	52
190	2,695	7	70
250	3,547	7	74

Ordinarily briquets may be considered sufficiently coherent when the loss occasioned by dust and breakage involved in their use does not exceed 5 per cent. Both manufacturers and consumers should recognize the desirability of adapting the briquet to the use intended.

^a Briquets as fuel: Special Consular Report, vol. 26, p. 54.

^b Idem., p. 50.

HARDNESS AND TOUGHNESS.

The briquet should be sufficiently hard; but if too hard it is likewise brittle, and therefore less coherent when subjected to rough handling. It is usually advantageous, therefore, to make the briquet of the minimum hardness that will suffice for the purpose in view. A briquet can be made harder by using a binder with a higher softening (melting) point. Consequently, if pitch is used, the most brittle pitch makes the hardest briquet. Moreover, a larger percentage of the more brittle pitch is usually required.

The requirement of the French Admiralty is that the briquet should not soften at 60° C. (140° F.). Ordinarily it is sufficient that the briquet shall not soften on the hottest day, and shall behave satisfactorily on burning.

DENSITY.

It is sometimes specified that the briquet should have a density of not less than 1.19. Perhaps a better standard would require the briquet to about equal in density the lump coal from which the slack was derived, thus ranging from 1.1 to 1.4. The density is increased by pressure.

SIZE AND SHAPE.

The convenience of a briquet for a given purpose, and hence the extent of its use, will depend largely on the size and shape. Attention is therefore called to the following points:

Heavy rectangular blocks allow a large output for the investment and are consequently cheaper to manufacture. They are convenient for storage. The French naval estimates show that 10 per cent more in weight of briquets can be stored in a given space than of lump coal, and the British Admiralty reports show a gain of as high as 20 per cent. Large rectangular briquets have the disadvantage of large smooth surfaces and are usually broken up when fed into furnaces, as this appears to promote combustion. To facilitate the breaking they are pressed with grooves or perforations. This gives better air circulation but decreases the output and the possibility of storage by just so much.

Prismatic shapes with rounded edges are most popular abroad. Either these or ovoid shapes of less than 2 pounds weight are preferred for domestic use. The rounded edges cause much less dust and breakage on handling and insure good air circulation and thorough combustion, but are wasteful in space and make the briquet somewhat harder to ignite.

The output of hollow, cylindrical, polygonal, and ball-shaped briquets abroad is small, the other shapes having proved more generally preferable.

WEATHERING.

The briquet should stand long exposure to the weather with but little deterioration. A dense briquet will stand the weather better than a porous one. In the process of manufacture briquets are liable to crack if they lack the proper proportion of binder, or if the binder and coal particles have been improperly mixed, or if the briquets are pressed too wet, or are insufficiently pressed. If the coal is finely ground, the briquet assumes a more dense and polished surface and is then more resistant to the weather. Cracks, however produced, allow the entrance of moisture and cause a rapid deterioration of the briquet on exposure to the weather. Lignite briquets, owing probably to the tendency of the lignite to absorb water and also to the more porous structure of the briquet, do not stand long exposure to the weather as successfully as other briquets.

The binder used must be insoluble in water. The great obstacle to the successful use of starch, molasses, and sulphite-liquor residues as binders is their solubility, the cost of rendering the briquet waterproof being usually prohibitive. It is deserving of serious consideration whether or not in certain dry portions of the West, where fuel is scarce, the waterproofing of the briquet could not be dispensed with altogether during the dry season, and to a considerable extent during the rainy season by keeping the briquets under cover.

With pitches, tars, etc., a slightly increased percentage of binder is necessary in briquets that are to stand long exposure to the weather. Further details are given under the discussion of the various binders.

ABSORPTION.

The briquet should not absorb more than about 3 per cent of moisture. The amount of moisture absorbed is increased when either the slack itself or the briquet is porous, or when the binder used has a tendency to attract moisture.

BURNING QUALITIES.

Readiness of ignition.—The ease with which a briquet will ignite depends largely on the slack used, but can be regulated to some extent. Large briquets ignite less readily than small ones. Sharp edges are an aid to ignition, though this advantage is not so great as to overcome the general preference for the prismatic and egg-shaped briquets. Briquets made from fine slack ignite less readily than those from coarser slack. A dense briquet is also more difficult to ignite. The use of an inorganic substance, such as clay or magnesia, as a binder, or as a constituent of the binder, tends to make the briquet ignite less readily. Increase of inorganic material—that is, ash—in the slack coal used produces the same result.

Kind of flame.—The briquet should burn with a clear, intense flame, and without odor or smoke. The burning of the briquet and the flame produced, as well as the smoke given off, will depend largely on the quality of the slack coal used and on the completeness of the combustion. The completeness of combustion can be regulated to some extent in the manufacture of briquets by making them of a shape to insure a good air circulation and by the choice of a suitable binder. So far as the choice of a binder for this purpose is concerned, the principle involved may be summed up in the statement that the smoke does not depend on the total amount of volatile matter in the briquet, but only on that part of the volatile matter which escapes before it is heated to the kindling temperature. In other words, the binder should not volatilize before the temperature is sufficiently high to insure complete combustion of the gases formed. In general terms, therefore, a binder adds smoke in proportion to the amount of low-boiling constituents (oils, etc.) that it contains.

Inorganic binders, of course, produce no smoke. Such organic binders as starch, molasses, or sulphite-liquor residues likewise do not volatilize until decomposed, and hence do not smoke, or smoke but little. Pitches, tars, and petroleum residues, when used as binders, volatilize, and will cause smoke and possibly odor if the gases formed are not completely burned. But it is quite possible to regulate the conditions, even when using these binders, in such a way that the briquets will produce less smoke than the lump coal from the screenings of which the briquet is made. This is due to the regular shape of the briquet, which allows a better-regulated air supply, enabling more complete combustion to take place. This reduction of the smoke nuisance is one of the advantages to be derived from the use of briquets.

Retention of shape.—The quality of retaining its shape in the fire is very important and depends on the properties of both the coal and the binder used in making the briquet. This point is discussed more fully in connection with the various coals and binders examined. The principle involved is very simple. The binder must hold the coal particles together until they are sufficiently softened to cohere. The temperature at which different coals soften or cake together varies greatly. Some bituminous coals cake readily at a low temperature, others less so. Semianthracite coals follow next in order, and then anthracite coals, some of the very hard anthracite coals with only a small amount of volatile matter showing little tendency to cake. Lignites as a class do not cake readily. Some, however, as those from Oklahoma or New Mexico, will cake sufficiently at a rather high temperature to hold themselves together. Others, as some California, Texas, or North Dakota lignites, show practically no tendency to soften or cake at any temperature. With such lig-

nites it is extremely difficult to make a briquet that will retain its shape in the fire. Briquets satisfactory for domestic use, when properly managed, can be made from such lignites. These briquets might be used in a variety of manufacturing operations if a grate suitably adapted to the fire box is provided. For use in a locomotive they would be less suitable.

With a readily caking coal, a binder that volatilizes (boils) at a comparatively low temperature may be used. With coals that cake at higher temperatures a less volatile binder must be used to obtain a satisfactory result in the fire. With a lignite that does not cake, the only binder that will enable the briquet to retain its shape until completely consumed is an inorganic binder which does not volatilize at all—unless, indeed, sufficient binder is added to practically coke the briquet. With such lignites, organic binders that do not volatilize, such as starch, molasses (in the form of waste residues from the sugar factories), sulphite-liquor residues from the paper mills, etc., give results that are fairly satisfactory, the briquet retaining its shape until the binder is itself decomposed. As the inorganic binders add ash and the other nonvolatile binders mentioned are not waterproof, it would seem generally better, where commercially possible, to mix a coal that will not cake of itself with a sufficient quantity of caking coal. Then when a suitable binder is used the briquet will retain its coherence in the fire by the softening of the caking coal used. The relation between the caking of a coal and its constitution is not well understood.

Percentage of ash.—The amount of ash left when the briquet is burned is the sum of that contained in the slack and in the binder used. Organic binders, as a rule, contain a smaller percentage of ash than the slack coal, and therefore slightly decrease the total percentage of ash in the briquet. When inorganic binders are used the ash thus added is a decided disadvantage.

In some foreign countries only 6 per cent of ash is permitted under many of the contracts for briquets. When the ash content of the slack exceeds 6 per cent it is therefore quite common abroad to wash the slack coal before briquetting. This saves freight on an incombustible material, saves binder, and gives in every way a better and more concentrated fuel. In this country, where good coal is so much cheaper than abroad, it will probably not usually prove feasible to wash the slack coal.

EVAPORATION RESULTS.

Theoretically the heating value of a briquet is the sum of the heating values of the coal and of the binder; and it can not possibly exceed this amount. Organic binders usually equal or exceed in heating value, weight for weight, the slack coal used. Usually,

therefore, they increase the total heat in a given weight of fuel, but owing to the small percentage of binder added, this increase is relatively slight. But the briquets have the advantage over the coal in that their burning is accompanied with less waste and they permit a better-regulated and more complete combustion to take place. In this way the heating value actually obtained from the fuel, weight for weight (and this, of course, is the important consideration), may be materially increased by the manufacture of the fuel into briquets. This increased heating value of the briquets over that of the slack used thus becomes a matter of practical importance.

The evaporation results should at least equal those of the best lump coal from the screenings and dust of which the briquet was made.

CONDITIONS GOVERNING THE USE OF BINDERS.

MAXIMUM COST ALLOWABLE FOR BINDER.

The output of a briquet plant depends to a very great extent on the size of the briquets manufactured. The cost of labor depends greatly on the size and arrangement of the plant and on the wages paid, which will vary considerably in different localities. The price of slack coal and of the different binders is even more dependent on the locality. An approximate idea of the total cost of manufacture, exclusive of the cost of the slack coal and the binder used, is here presented, in order to consider intelligently estimates which may be made of the maximum allowable cost of the binder, it being obviously useless to investigate a binder that could never be commercially used on account of its cost. E. Loze^a estimates the cost for manufacture in France at 33 to 40 cents per ton. Schorr^b states that the cost in France is 24 to 34 cents per ton; in Germany, 22 cents to 24 cents; and in England, 24 cents. Estimates of the cost in the eastern and western parts of the United States are as follows:

Estimated cost per ton of manufacture of briquets in the United States (exclusive of binder and of coal briquetted).

	Western States.	Eastern States.
Labor, inclusive of stacking.....	\$0.16	\$0.20
Oil and grease.....	.006	.01
Sundry stores.....	.01	.01
Steam (fuel).....	.04	.17
Depreciation.....	.05	.10
	.266	.49

Considering 30 to 50 cents per ton, therefore, as being approximately the cost of manufacture, it appears that when the difference in price

^a Eng. and Min. Jour., vol. 76, 1903, pp. 277, 431.

^b Trans. Am. Inst. Min. Eng., vol. 35, 1904, p. 100.

between the slack coal and the first-class lump coal is \$1, the binder must cost less than 50 to 70 cents per ton. Good briquets would probably find in many places a market at a price slightly advanced over that of the corresponding lump coal from the screenings of which the slack was derived. Yet it is evident that the main problem in briquetting is to find a suitable binding material at a cost sufficiently low. A binding material costing as much as \$1 per ton of briquets produced could be used profitably in but few places in the United States. Even allowing for future possible greater variation in price between the coal and the slack it is not necessary to pay attention to any binding material costing above \$1.25 per ton of briquets produced.

QUALITIES DESIRED IN BINDERS.

It is needless to say that a desirable binder should make a good briquet and should make it cheaply. The characteristics of a good briquet have already been pointed out. It will not, perhaps, be too great a repetition to summarize here, in the approximate order of their importance, the desirable qualities of a binder, as follows:

1. It must be sufficiently cheap to make the manufacture of briquets profitable.
2. It must bind strongly, producing a briquet sufficiently hard, but not too brittle.
3. It must hold the briquet together satisfactorily in the fire.
4. It must produce a briquet sufficiently waterproof to stand the conditions of use.
5. It should not cause smoke or foul smelling or corrosive gases, or foul the flues.
6. It should not increase the percentage of ash or clinker.
7. It should increase, or certainly not diminish, the heat units obtainable from a given weight of fuel.

EFFECT OF QUALITY OF BINDER ON THE BRIQUET.

SCOPE OF THE INVESTIGATIONS.

The behavior of a large number of different coals with a few binders and of a few coals with a large number of different binders has been very carefully studied. Tests were made with each coal and with each binder until the percentage of binder required to produce a satisfactory briquet with that coal was determined. The behavior of the briquets in the fire and, when necessary, in water was noted. The binders used were examined as to their chemical or physical properties and such modification of the binder was made as seemed likely to produce more efficient results.

The conclusions that follow are submitted as the net result of the studies thus outlined.

PHYSICAL RELATION OF COAL AND BINDER.

The relation between the coal and the binder is purely physical. Chemical action, if coming into play at all, is so slight in amount as to be wholly negligible. Moreover, the properties of the binder are not greatly changed by the mutual solubility, or surface action, of coal and binder at the surface of the coal.

The above statements are shown to be true by the fact that if the coals are arranged in a series according to the percentage of one binder required, they will retain that same order when other binders are used, even when these binders are of the most diverse nature. The experiments of Constam and Rougeot^a show that the soluble portion of the binders (various pitches) could be extracted from the briquets practically quantitatively with carbon disulphide, and that this reagent extracted at the most only 0.7 per cent from the coal.

The properties of the briquet are the properties of the coal plus the properties of the binder, and the combination of the two in briquetting does not materially change the properties of either. Not only is this observation true of briquets at ordinary temperatures, but it is also confirmed by their behavior in the fire. The decomposition of the binder caused by the heat may alter its character to some extent, but never, so far as the writer has observed, sufficiently to mask its original character. The action of the briquet in air and in water also confirms the truth of the above observation.

QUALITIES OF BINDER IMPARTED TO BRIQUET.

If the binder is brittle the briquet will be relatively brittle at the same temperature. Thus rosin, hard pitches, asphalts, cements, etc., make briquets that are hard, but they break easily from a sharp blow or fall. Liquids such as coal tar, creosote, asphalt tar, etc., make briquets that do not break easily from a fall, but they yield so readily to pressure as to be useless. Comparable percentages of binder being used, the toughest briquet—that is to say, the briquet that will stand the most rough usage—is made with a binder that at ordinary temperature twists easily and pulls into threads, that will cut with a knife rather than break, and that flows very slowly, taking some time to assume the shape of the container. Such a binder is sufficiently elastic not to be brittle and is sufficiently stiff not to yield to climatic changes of temperature. Binders that have been examined fulfilling this condition are pine-wood tar (12),^b water-gas tar pitch (39), wax tailings (40), and residuums from petroleum, often designated as asphalts (37 A, 37 B, and 37 C). Satisfactory briquets are made with 3 to 5 per cent of the above binders. If the coal does

^a Zeltschr. f. angew. Chemie, vol. 17, No. 26, p. 1.

^b Numbers refer to list on p. 22.

not cake readily a binder with a higher melting point would be required to make the briquet retain its shape in the fire.

BEHAVIOR WHEN HEATED.

The binder will soften when in the briquet as soon as it is heated to the temperature at which it softens when outside of the briquet. Such softening will not be so apparent, however, for the binder exists in the briquet as a very thin coating over the grains, and if it melts to a thick, sticky liquid, rather than to a limpid one, its cohesive power in the state of a liquid is still very great. But it must be borne in mind that all briquets have a temperature of maximum weakness in the fire. This temperature lies in the interval between the melting or destruction of the binder and the softening of the coal as it commences to cake. If the coal softens at a high temperature the binder must melt at a relatively high temperature to give satisfactory results in the fire. If the coal does not cake at all, then the binder must not melt at all, or be destroyed by the heat, if a perfectly coherent briquet at all temperatures is desired. Only inorganic binders could fulfill this condition, and their use is objectionable. Organic binders that do not melt, such as starch, etc., give the best results in the fire with a noncaking coal, but are not waterproof.

In a furnace the briquet does not become thoroughly heated throughout at the same time, and as the binder near the surface of the briquet melts and passes out as a gas, the binder in the next interior layer of the briquet to some extent takes its place, and so on. In this way the briquet is held together until the coal at its surface softens and cakes. When this happens the briquet commences to regain its strength and with many coals soon becomes stronger than when placed in the fire.

The binder will volatilize out of the briquet and appear as a gas as soon as it reaches the temperature at which it boils when outside of the briquet and in the pure condition. If this happens much below the kindling temperature of the gas some smoke and odor will be caused, and the smoke and odor may to a large extent be taken as proportional to the low-boiling oils in the binder—at least so far as the smoke is caused by the binder and not by the coal.

SOLUBILITY.

If the binder used is to any extent soluble in water the briquet will not withstand exposure to wet weather. The binder will go into solution as surely, though more slowly, in the briquet, as when it exists in the pure condition outside of the briquet, unless the briquet is in some way rendered waterproof.

QUANTITY OF BINDER NECESSARY.

SURFACE TO BE COATED.

The fact that the binder exists unchanged in the briquet, its office being solely to coat the grains, fill up void spaces between the grains, and by its adhesive and cohesive properties hold the briquet together, points to the following conclusions.

The amount of binder required will depend on the amount of surface to be coated, and the amount of surface will depend on the size of the grains, on their density (that is, the density of the dry coal), and on the capillary pores in the coal. The theoretical relation between the amount of surface to be coated, the size of the grains, and the density of the coal can be easily computed.

Let w = weight of coal taken. Suppose the grains of coal to be spheres, and let r = radius of the sphere. Let d = density of the coal. Then the volume of the sphere is $\frac{4}{3} \pi r^3$. The weight of the sphere is $\frac{4}{3} \pi r^3 d$. The number of grains of coal in the weight of coal taken is $\frac{w}{\frac{4}{3} \pi r^3 d}$. The surface of each grain is $4 \pi r^2$, and the total surface to be coated is $\frac{3w}{rd}$.

That is, the amount of surface to be coated varies inversely with the density of the coal and inversely with the diameter of the grains. The same law can be shown to apply whatever the shape of the grains.

The practical bearing of this relation is important. Thus, suppose a coal of density 1.4 requires 6 per cent of pitch to make a satisfactory briquet. Then a coal of density 1.1, other things being the same, would require 7.63 per cent of pitch, or 1.63 per cent more pitch than is required by the denser coal. This is one reason why lignite coal with a low specific gravity requires more binder than the average coal.

The variation in the size of the grains of coal has an even greater influence on the amount of binder required. The table below shows the relative amount of surface to be coated in coal slack of varying degrees of fineness:

Relation between size of grains and amount of surface.

Number of meshes to inch.	Diameter of wire (inch).	Size of mesh (millimeters).	Relative amount of surface.	Number of meshes to inch.	Diameter of wire (inch).	Size of mesh (millimeters).	Relative amount of surface.
1.....	0.131	25.400	1	80.....	0.00575	0.230	110
2.....	.103	12.700	2	100.....	.00450	.170	150
4.....	.079	6.350	4	200.....	.00235	.085	300
10.....	.027	2.000	12.7	.....	.....	.005	5,080
20.....	.01650	1.000	25.4	.....	.....	.0025	10,160
30.....	.01375	.670	37.9	.....	.....	.00075	33,900
40.....	.01025	.500	50.8	.....	.....	.00025	101,600
50.....	.00900	.310	81.9	.....	.....	.....	.....

It will thus be seen that coal slack which will just pass a 20-mesh sieve has 6.35 times as much surface to be coated as the same weight of slack crushed so as to pass a screen of $\frac{1}{4}$ -inch mesh, and that coal passing a 200-mesh sieve has 75 times the surface of coal just passing the $\frac{1}{4}$ -inch mesh. The very finest dust, having a diameter of 0.00025 millimeter, has 25,400 times the surface of coal just passing the $\frac{1}{4}$ -inch mesh.

This consideration is not purely theoretical. The remark of Wagner,^a that it took 20 per cent of pitch to briquet certain fine coal dust, is illustrative of its practical bearing. The degree of fineness of the slack coal used is one of the main factors in determining the percentage of binder necessary to produce a satisfactory briquet.

To illustrate this point, mention is here made of a fact shown later, that all coal-tar pitches contain a certain amount of carbon (soot), which, being in a very finely divided condition, is not only inert so far as binding the coal together is concerned, but itself requires a binder. Owing to the dustlike condition of this carbon its effect on the binding power of the pitch for the coal is most marked. Thus, although a coal-tar pitch (28 G) that contained 14 per cent of this inert, finely divided carbon made a satisfactory briquet with Illinois No. 4 coal when 6 per cent of the pitch was used, yet another coal-tar pitch (28 I) containing 37 per cent of the inert carbon failed to make a satisfactory briquet with the same coal when 14 per cent of the pitch was used. On the market the pitches sell at approximately the same price. The serious mistake made in crushing coal slack too fine is apparent.

Fine crushing of the coal slack gives the briquet a smoother surface that is more resistant to the weather; but this increase in the quality of the briquet is usually obtained at too great a cost, owing to the additional binder required, as explained above. Fine crushing also makes the briquet somewhat harder to ignite.

Capillary pores increase the amount of surface to be coated and the amount of void space to be filled, and this is probably another reason why lignites require more binder than hard coals.

It is interesting, in this connection, to note that with all binders the coherence in the briquets at first increases but slowly with increase in the proportion of binder. Then suddenly the coherence increases very rapidly and the briquets become strong. Then when an excess of binder is added the increase in strength is again only slight. The curve takes the form indicated in the accompanying diagram (fig. 1). The explanation, of course, lies in the fact that at first there is not enough binder to coat all the grains of coal and there can be little coherence. When sufficient binder has been added to coat the grains, the strength increases rapidly. After the grains have been well

^a Cassier's Magazine, vol. 11, 1896, p. 23.

coated there is little further gain in strength with the use of additional binder.

PERCENTAGE OF VOIDS.

The amount of binder will depend on the amount of void space to be filled. There should always be enough of the finer coal and coal dust present to fill the spaces between the larger grains, or binder will be required to fill these spaces. Thus Wagner also found that a very large amount of binder was required to bind coal slack of a uniform size, five-sixteenths to three-eighths inch in diameter. Clifford Richardson, in a recent book on "Modern asphalt pavements," gives a calculation by Dr. G. F. Becker, of the United States Geological

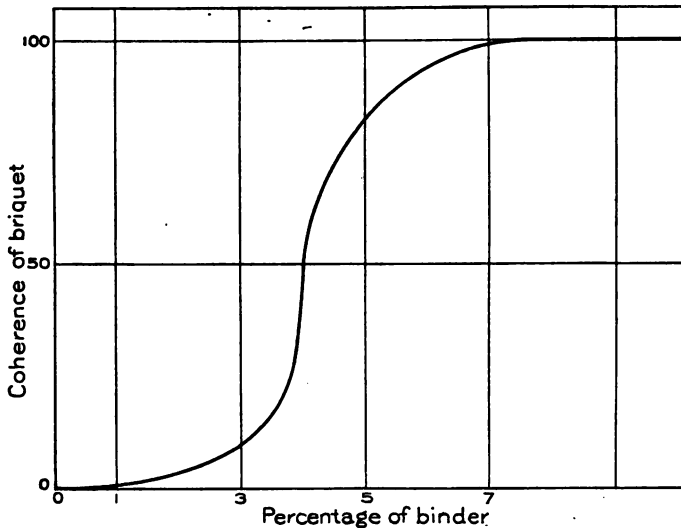


FIG. 1.—Curve showing relation between percentage of binder (water-gas tar pitch) and coherence of briquet. Other binders show similar curves, but with different percentages.

Survey, as to the amount of void space. This calculation is in outline as follows:

Consider four spheres in a plane so arranged that the lines joining their centers form a square, and four other spheres above them. A cube is formed by the lines joining the centers of the eight spheres. If r is the radius of a sphere, then the volume of the cube is $8 r^3$ and the void space is $8 r^3 - \frac{4}{3} \pi r^3$, and the percentage of void space is $\frac{8 r^3 - \frac{4}{3} \pi r^3}{8 r^3} = 1 - \frac{\pi}{6} = 0.4764$. If the spheres are placed obliquely, then the area of the parallelogram joining their centers is $2 r^2 \sqrt{3}$, and multiplying this by the height of a tetrahedron formed by the centers of four spheres when three are placed in contact in one plane

and the fourth is placed on them, we have for the volume of the prism $4\sqrt[4]{2} r^3$. Then for the percentage of voids we will have

$$\frac{4\sqrt[4]{2} r^3 - \frac{4}{3}\pi r^3}{4\sqrt[4]{2} r^3} = 1 - \frac{\pi}{3\sqrt[4]{2}} = 0.2595.$$

From these results it will be seen that the amount of void space between grains of uniform size is independent of the size of the grains. In practice, however, even shot will not pack quite so closely as the theory indicates, as is shown by the experiments of Richardson, who found that with shot the percentage of void space was about 32.^a

With grains of sand of uniform size but of irregular shape Richardson found the void space to average 43.6 per cent. It may be said, therefore, that in briquetting coal, 56.4 per cent of the total weight of the slack should be in grains about one-fourth inch in diameter.

It is interesting to obtain some idea of the desirable fineness of the remaining coal particles. Without giving the calculation in detail we may say that theoretically the spheres fitting in the spaces between the larger spheres, and the yet smaller spheres fitting into the void places then left can be calculated. The calculation shows that if r represents the radius of the large sphere there would be for every large sphere one smaller sphere having a radius of .4142 r , two spheres having a radius .2247 r , five spheres having a radius .1763 r , and eight spheres having a radius .1543 r . The volume occupied by these smaller spheres will be 11.14 per cent of the total volume, and since the large spheres occupy 74.05 per cent of the total volume, we would have about 15 per cent of void space to be filled in by yet smaller spheres. With irregular grains the results would not follow the theoretical percentages; but in a general way it is apparent that although it is advantageous to have a large percentage of the grains coarse (say 60 per cent of $\frac{1}{4}$ -inch diameter), yet a considerable amount (say 40 per cent passing a 20-mesh sieve) of the finer slack and dust must be present to fill the voids.

The coal used in briquetting being already for the most part fine slack, the best practical results will be obtained by not breaking any of the lumps that are larger than one-fourth inch in diameter more than is necessary to bring them to that diameter and by not crushing the finer coal at all.

THICKNESS OF COATING.

The amount of binder necessary will depend on the thickness of the coat of binder over the surface of the grains of coal. The thickness of the coat of binder required will vary both with the coal and the

^a This is partly accounted for by the fact that the discussion of Doctor Becker does not consider the contact of the spheres with the walls of the container.—J. E. M.

binder, but principally with the binder. In general, it may be said that the binder should be dissolved or heated until it is in the condition of a thin liquid capable of wetting the grains, somewhat as water would. With the harder pitches or asphalts, and similar binders, superheated steam for the mixers is a matter of necessity for economical working, for otherwise the binder does not become sufficiently liquid to spread in a thin coat and is therefore wasted.

OTHER CONSIDERATIONS.

The amount of binder required will depend to a slight extent on that portion of the coal which, being soluble in carbon disulphide, may be regarded as "bitumen" and as having some binding power. Constam and Rougeot^a never found the amount of carbon disulphide extract to exceed 0.7 per cent, and probably with most coals the amount is negligible.

If the coals are arranged in a series according to the percentage of one binder required they will retain that same order in the series when other binders are used. Furthermore, if the equivalent percentages of different binders are determined for one coal then these equivalent percentages can be used for all coals, slight modifications only being sometimes necessary. An advantageous arrangement would be to place coals as ordinates and binders as abscissas in a table, and then the percentages of any binder required with any coal could be read directly.

LABORATORY INVESTIGATIONS OF VARIOUS BINDERS.

METHODS AND SCOPE OF THE EXAMINATION.

DETERMINATION OF PERCENTAGE OF BINDER.

In order to determine in the laboratory the percentage of pitch necessary to briquet a given coal, 20 grams of coal, unless otherwise stated in the detailed report, was weighed out, mixed with the chosen percentage of binder, and placed in a Battersea crucible. A small amount of water was then added and the mixture heated, with sufficient stirring to mix the binder and coal thoroughly, until steam came off freely and only a small amount of water was left in the coal. The mixture while still hot was pressed in a small laboratory hand press, on which a pressure of 3,500 to 4,000 pounds per square inch was usually obtained. Each briquet made weighed about 5 grams, and thus four briquets were obtained as representing the test. The percentage of binder was varied in subsequent tests until the correct percentage to produce a satisfactory briquet was determined.

The percentage of binder was always calculated on the weight of the coal, consequently the percentage calculated on the weight of the

^a Zeitschr. f. angew. Chemie, vol. 17, No. 26, p. 1.

briquet produced would be somewhat less. This is a matter of no consequence, however, as the method of grading the briquet was purely relative.

DETERMINATION OF COHERENCE.

The examination of the small briquets produced was somewhat crude—their coherence being determined by the way in which they crushed or broke. The briquets were graded by numbers as follows:

- | | |
|------------------------------------|--|
| 1. Very slight coherence. | 4½. Excellent briquet; would stand rough handling. |
| 2. Slight coherence. | |
| 3. Coherent, but not satisfactory. | 5. A briquet stronger than necessary. |
| 4. Satisfactory. | |

It was found somewhat difficult to compare extremely hard and brittle briquets with others not brittle but too soft. In all tests the intention was to produce a relative grading in which 4 would represent a satisfactory briquet for ordinary use. In actual work the coherence of the briquet could be varied to suit the demand of the customer, but in no case probably would such variation exceed the range represented by the numbers 3½ to 4½.

LIST OF MATERIALS STUDIED.

The materials used to bind the particles of coal together may be either organic or inorganic, and a very large number of substances have at various times been suggested and used for this purpose.

A list of the binders which have been examined is given below. An effort has been made to include in this list all binders which it was thought might be used commercially in the United States, as well as certain other substances which seemed fitted to throw light on the laws governing the action of the binder. Attempt was made to study such modifications and combinations of the different binders as it seemed might produce more efficient commercial results. For these latter modifications and combinations reference must be had to the detailed report.

INORGANIC BINDERS.

(1) Clay, (2) lime, (3) magnesia, (4) magnesia cement (magnesium oxide and magnesium chloride), (5) plaster of Paris, (6) Portland cement, (7) natural cement, (8) slag cement, (9) water glass.

ORGANIC BINDERS.

Wood products.—(10) Rosin, (11) pitch (rosin and tar), (12) pine-wood tar, (13) hard-wood tar, (14) Douglas fir tar, (15) wood pulp, (16) sulphite liquor (from paper mills).

Sugar-factory residues.—(17) Beet pulp, (18) lime cake, (19) beet-sugar molasses, (20) cane-sugar molasses.

Starch.—(21) Corn starch, (22) potato starch.

Slaughter-house refuse.

Tars and pitches from coal.—(23) Blast-furnace tar, (24) producer-gas tar, (25) illuminating-gas tar, (26) by-product coke-oven tar, (27) coal-tar creosote, (28) various grades of pitches from various tars.

Natural asphalts.—(30) Impsonite, (31) gilsonite, (32) maltha, (33) refined Trinidad, (34) refined Bermudez, (35) hard and refined asphalts (from impregnated sandstones, etc.).

Petroleum products.—(36) Crude oil, (37) residuum (asphalts, etc.), (38) water-gas tar, (39) water-gas tar pitch, (40) wax tailings, (41) acid sludge, (42) asphalt tar, (43) Pintsch gas tar, (44) Pittsburg flux.

INORGANIC BINDERS.

GENERAL STATEMENT.

The great disadvantage of inorganic binders is that they all add ash to the fuel. This means freight on just so much noncombustible material, less heat return for a given weight of fuel consumed, and an added amount of ash on the grate. All briquets made with inorganic binders are weak when first pressed and strengthen only gradually. Inorganic binders possess the advantage that they are not volatile, and hence the briquets, even when made from a noncaking coal or lignite, will stand up well in the fire without disintegration. They also have a tendency to lessen the smoke produced. This is due to the fact that the binder enables a somewhat slower and more complete combustion to take place and does not itself contribute any smoke to the fuel.

Another slight advantage sometimes claimed for certain of the inorganic binders, such as lime, water glass, and magnesia, results from the tendency of the calcium, sodium, and magnesium to combine with the sulphur, thus diminishing the escape of the sometimes objectionable oxidation products of that substance. This action would be the same if the calcium, etc., existed in the binder in chemical combination, as it occurs in calcium resinate. (See "Rosin," p. 30.) For the purpose of testing the above-mentioned claim, a briquet was made with Indiana No. 8 coal and 4 per cent of magnesium oxide. The briquet was dried and then burned. The sulphur in the ash (determined by the kindness of Mr. Somermeier) was found to amount to 0.44 per cent. As the sulphur in the coal was 3.72 per cent, it is evident that only a small fraction of the sulphur is retained by the magnesium oxide used as a binder. The same would probably also hold true for calcium and sodium compounds. It is thought, therefore, that the advantage thus gained is not great enough to merit consideration in practice.

Evidently the disadvantage resulting from the addition of any large percentage of an inorganic binder is too great to justify its use except as a matter of great saving in cost, or as a matter of necessity, in order to hold together in the fire some entirely noncaking coal and produce a low grade of fuel therefrom.

The essential results of the tests made with the different coals and binders are assembled in the table at the end of this report, wherein is shown the percentage of binder necessary to produce a satisfactory briquet with the coal considered.

The work of the laboratory can be regarded as sufficient so far as the negative results are concerned, but in all cases where the laboratory work seemed to promise commercial results the experiments should be repeated on a larger scale.

The inorganic substances which were tested are the only inorganic materials whose use as a binder on a commercial scale seemed even so remotely possible as to warrant testing in the laboratory. A list of other inorganic substances which have been suggested as binders, or as possible constituents of binders, would include chalk, alum, ammonium chloride (sal ammoniac), copper sulphate, sodium hydroxide, sulphur, potassium nitrate, calcium chloride, etc. That all these substances are totally unfit for such purpose appears at once from a knowledge of their properties, and they were not considered further.

DETAILED DESCRIPTION.

1. *Clay*.—The tests shown in the table (pp. 51–52) were made with a good sample of potter's clay obtained through Dr. J. H. Pratt. Clay is cheaper than coal and its cost, considered as a binder, is therefore a minus quantity.

The briquets when first taken from the press were extremely weak, many of them breaking while being taken out. The full pressure could not be given, for the coal would crush through the narrow, practically closed space between the molds and the bed plate. After drying, the briquets were hard and rather brittle. In water they fell to pieces completely and quickly. In the fire they hardened and stood up well, except those made of the noncaking lignite, California No. 1, which nevertheless stood up far better than with most binders and in comparison with the usual behavior of this lignite could be called very satisfactory.

Clay was used as a binder at one of the first plants established in this country, the Loiseau plant at Port Richmond, Pa. Trouble was experienced with the press used, the briquets when first made showing weakness. This was finally overcome, but the binder was abandoned owing to the expense of drying and waterproofing the product. Briquets made at this plant with clay were said to be very satisfactory in the fire.

Any press using clay for a binder would probably have to be specially adjusted. Owing to the large addition of ash, and to the expense of drying and waterproofing the briquet, it is improbable that clay will ever prove advantageous as a binder. If used alone it

can only be for the manufacture of a poor grade of fuel, incapable of standing any exposure to rain.

Clay in connection with other binders may be regarded as an adulteration of very doubtful value to the consumer.

2. *Lime*.—Lime, or rather, milk of lime, $\text{Ca}(\text{OH})_2$, has often been suggested as a binder, and is said to have been used. The tests shown in the table were made with calcium oxide known to be chemically pure. In these tests the lime was mixed dry with the coal, and then water was added. In some of the tests an excess of water was added and later boiled off; in others an excess of water was added and then squeezed out in the press; and in yet others only sufficient water was added to thoroughly moisten the mass. After drying, all the briquets were very weak, those in which the largest percentage of calcium oxide was used being the worst. They finally disintegrated, merely from exposure to the air.

From these tests it is difficult to understand how it is possible to use lime alone to make a briquet. For further experiments with lime see "Rosin," (p. 30).

3. *Magnesia*.—The sample of magnesia tested was a light, calcined magnesium oxide. In the tests shown in the table (pp. 51–52) the magnesium oxide was mixed with the coal and then a sufficient amount of water was added. In some tests the briquet was pressed cold and in others more or less of the water was evaporated. The results show that 3 to 5 per cent of this binder would make a satisfactory briquet, except with certain lignites. The briquets are very hard and would stand heavy pressure, but are brittle if less than 4 per cent of binder is used. In water the briquets go to pieces, though far less rapidly than those made with clay. In the fire they behaved very well, some being satisfactory even when only 2 per cent of binder was used.

In the United States magnesite, from which magnesia is obtained, is found only in California, where the production of magnesium oxide in recent years has been as follows:

Quantity and value of magnesia produced in the United States, 1901–1906.

Year.	Quantity.	Value per ton. ^a	Year.	Quantity.	Value per ton. ^a
	<i>Short tons.</i>			<i>Short tons.</i>	
1901.....	1,666	\$7. 56	1904.....	1,357	\$8. 22
1902.....	1,349	7. 56	1905.....	1,873	9. 76
1903.....	1,750	7. 27	1906.....	3,714	7. 56

^a Based on value of raw magnesite, with 10 per cent added to cover cost of manufacture of magnesium oxide therefrom, being a suggestive approximation only.

The production could be greatly increased, several million tons of the magnesite being now in sight. The mineral is calcined for the

production of carbon dioxide, leaving the magnesia, which is used principally for covering steam and heating pipes, by paper mills, and in the manufacture of bricks for lining open-hearth furnaces and converters.

At the price prevailing in 1903, the cost of 3 per cent of this binder would be about 22 cents per ton of briquets produced. Three or four per cent of ash added to the fuel would not be greatly injurious, and the binder would possess an advantage over organic binders in holding the briquet together in the fire and in reducing the smoke.

The claim that the magnesia in the briquet reduces the amount of sulphur that escapes from the coal, as already pointed out (p. 23), seems to be of no practical importance.

It seemed possible that coke breeze might be briquetted with this binder, the briquets to be used in the place of coke in the furnace. Laboratory experiments on this point, however, gave unsatisfactory results, as follows:

Results of briquetting coke breeze with magnesia.

Percent- age of binder.	Grade of coher- ence. ^a
3	3
4	3
6	4
8	4½

^a See p. 22.

In water the briquet with 6 per cent of magnesia behaved fairly well and that with 8 per cent splendidly, but in the fire the briquet with 4 per cent was unsatisfactory, that with 6 per cent was only fair, and that with 8 per cent was very hard to ignite.

For results of experiments with mixtures of magnesia and organic binders see p. 49.

4. *Magnesia cement.*—In 1880 Dr. A. Gurlt recommended a binding material consisting of 30 parts of 45 per cent magnesium chloride, 30 parts of 93 per cent magnesium oxide, and 60 parts of water. He used 5 per cent of this material and says that it produced a stronger briquet than any other and that it adds only 2.5 per cent of ash. The statement as to the amount of ash (magnesium oxide) added is correct. The formula on examination, leaving out the water, is found to reduce to $5\text{MgO}.\text{MgCl}_2$. The evidence on which this formula was taken as the most advantageous for the cement is not stated. The results reported in the following table are based on the proportions shown for the formulas therein given:

Results of briquetting Illinois No. 11 B coal^a with varying formulas of binder.

Formula.	Calculated for 2 per cent of magnesium oxide in the ash.			Calculated for 3 per cent of magnesium oxide in the ash.			Remarks.
	Amount of binder per gram of coal.		Grade of co-her- ence. ^b	Amount of binder per gram of coal.		Grade of co-her- ence. ^a	
	MgO.	MgCl ₂ 6H ₂ O.		MgO.	MgCl ₂ 6H ₂ O.		
	<i>Gram.</i>	<i>Gram.</i>		<i>Gram.</i>	<i>Gram.</i>		
MgO. MgCl ₂	0.0100	0.0500	2½	0.0150	0.0750	3	} Stronger than preced- ing.
2MgO. MgCl ₂.....	.0133	.0334	2½	.0200	.0500	3
3MgO. MgCl ₂.....	.0150	.0250	2½	.0225	.0375	3
4MgO. MgCl ₂.....	.0160	.0200	2½	.0240	.0300	3
5MgO. MgCl ₂0167	.0167	3	.0250	.0250	3½	} Apparently of about equal strength.
6MgO. MgCl ₂.....	.0171	.0145	3	.0256	.0216	3½
7MgO. MgCl ₂.....	.0175	.0127	3	.0262	.0190	3½
MgO.....	.0200	.0000	3	.0300	.0000	3½	

^a Bituminous coal (one-half run of mine, one-half lump) from shaft near Carterville, Williamson County, Ill. For description, analysis, and tests see Bull. U. S. Geol. Survey No. 290, 1906.

^b See explanation under "Determination of coherence" (p. 22).

In these tests the magnesium oxide was mixed dry with the coal, and then the magnesium chloride (dissolved in water) was added. As already stated, the method of testing the small briquets made does not allow of minute differences being noted, but the results showed clearly an increase of strength until the proportion given by Doctor Gurlt and represented by the formula 5MgO.MgCl₂ was reached. On still further decreasing the proportion of the magnesium chloride the briquets apparently did not grow either weaker or stronger. Magnesium oxide is cheaper than the chloride, and in view of the results obtained there is considerable doubt as to the advantage of adding the chloride. The addition of the chloride is said to make a more quickly setting cement, and one that is more insoluble, owing to the formation of an oxychloride of magnesium, but the statement is not verified. The magnesium chloride would also have the disadvantage of losing its chlorine in the fire, and this might come off either free or combined with hydrogen as hydrochloric (muriatic) acid. In either case the resulting gas is exceedingly corrosive and would greatly injure the boiler flues. Possibly all of the chlorine would be retained by the coal ashes, but it is a matter of grave doubt.

In the fire briquets made with 3 per cent of magnesia cement of the formula 5MgO.MgCl₂—that is, 3 per cent after calculating the formula to MgO—stood up well. In water they disintegrated after some time. It was not evident that the briquets with magnesia cement of this formula behaved any better in water than briquets made with the same ash percentage of magnesium oxide alone, if indeed they behaved so well.

Magnesium chloride is ordinarily sold in the market in the crystallized form MgCl₂.6H₂O. This grade is quoted at \$20 per ton in large lots in New York. It is not produced to any considerable extent in this country, but should the demand arise could probably be made from the California magnesite without increasing the cost.

All the briquets made with the magnesia cement were very hard but very brittle. They would stand great pressure, but apparently would not stand rough handling, when only 5 per cent of the cement is used, as recommended by Doctor Gurlt.

5. *Plaster of Paris*.—Gypsum, the mineral from which plaster of Paris is produced, is widely distributed in the United States. In 1903 the production was 264,196 tons, valued at \$4.08 per ton.

The tests shown in the table (p. 51) were made with plaster of Paris which was first mixed with the coal. Sufficient water was added to thoroughly moisten the mass, and then pressure was applied, the excess of water, if any, running out in the press. The briquets were very hard, but also brittle, and would not stand rough handling unless at least 12 per cent of binder was used. Even these were not first-class briquets. In the fire the briquet with 12 per cent of binder held together perfectly, and would have held together with a smaller percentage. In water the briquet went to pieces more rapidly than was expected.

Although even 12 per cent of plaster of Paris in a briquet would not be prohibitive as regards cost (50 cents per ton of briquets produced), it would be as regards the addition of ash, and would moreover cause a much slower combustion of the briquet. A briquet with 6 per cent shows considerable coherence and might be satisfactory for some purposes. For results of experiments with mixtures of plaster of Paris and organic binders see page 49.

6. *Portland cement*.—In 1903, 22,342,973 barrels of Portland cement, weighing 400 pounds gross each, were produced in the United States. The average value per barrel was \$1.24, and allowing 20 pounds tare for the barrel, the value per ton was \$6.52.

The sample of Portland cement tested was obtained from Mr. Richard L. Humphrey and was a mixture of seven well-known brands, constituting what has been termed typical cement. In the first tests made the cement was mixed with the coal, then an excess of water was added and largely boiled off, after which the coal was pressed. The results not being satisfactory, in subsequent tests less water was added and the mixture was not heated, but the results were only a little better. In the fire briquets with 12 per cent of binder held together well, and a smaller percentage would have been sufficient. In water the briquets went to pieces somewhat more rapidly than those made with plaster of Paris.

This binder is more expensive and certainly no better than plaster of Paris. For results of experiments with mixtures of Portland cement and organic binders see page 49.

7. *Natural cement*.—In 1903 the production of natural cement in the United States was 7,030,271 barrels, of 300 pounds gross weight each. The average value was \$0.522 per barrel, equivalent to \$3.73 per ton, allowing 20 pounds tare for the barrel.

The tests were made with a sample from Louisville, Ky., which was mixed dry with the coal and then sufficient water was added before pressing. The results were very nearly the same as with Portland cement, the briquets being hard and brittle. In the fire the briquets held together excellently, but in water they would not stand up particularly well. Natural cement would make a cheap binder but would have to be used in such large quantity as to be very objectionable.

8. *Slag cement*.—In 1903, 525,896 barrels of slag cement, of 380 pounds net weight each, worth \$1.03 per barrel, equivalent to \$3.42 per ton, were manufactured in the United States. Tests were made with slag cement as with the other cements, the results indicating its inferiority to either the Portland or the natural cement as a binder for coal slack.

9. *Water glass*.—Water glass, or sodium silicate, is produced to a considerable extent in the United States, 32,651 tons having been manufactured in 1900, with an average value of \$12.74 per ton.

It is said that this material will make coherent briquets when 0.75 to 1 per cent is used. Two different samples were tested. The requisite amount was dissolved in hot water and mixed with the coal, any large excess of water was boiled off, and then the briquets were pressed. The results were unsatisfactory even when 12 per cent of binder was used. The experiments were then repeated with less water and no heat, but the results obtained were no more satisfactory. When the sodium silicate was analyzed one sample was found to contain only 86 per cent of the requisite amount of silica and 13.4 per cent of the requisite amount of sodium required by the formula for the normal silicate (Na_4SiO_4). The other sample, which behaved only a little better, showed on analysis 11.1 per cent of Na_2O and 27.4 per cent of SiO_2 . These poor analyses may account to some extent for the lack of success obtained with the water glass, but the results are apparently sufficient to show that it is not suitable for use as a commercial binder.

ORGANIC BINDERS.

WOOD PRODUCTS.

10. *Rosin*.—In 1900, 300,000 tons of rosin, valued at \$17.02 per ton, were produced in the United States. Of this amount, according to the Census report, only 7.6 per cent was used for domestic consumption. In 1905 the price of rosin, for even the lower grades, A to C, had risen to \$29 per ton.

Rosin consists mainly of abietic acid or similar isomeric acids or anhydrides. The formula of this acid is given as approximately $\text{C}_{40}\text{H}_{56}\text{O}_4$, and its acid equivalent as 145 to 185. This means that if calcium oxide is used to neutralize the acid 0.0725 to 0.0925 gram should be added to 1 gram of the rosin to form calcium resinate.

The density of rosin ranges from about 1.07 to 1.08. Rosin softens at 80° C. and melts to a limpid liquid at 100° C. The melting point of abietic acid is stated to be 165° C. Rosin is entirely soluble in carbon disulphide.

The sample of rosin tested melted at 100° C. The tests made are shown in the table (pp. 51-52). The briquets withstood exposure to the weather well and, except those made with lignites, were satisfactory in the fire, though inclined to smoke.

An attempt was made to see if the addition of lime would improve the binding qualities of the rosin. Three grams of rosin mixed with 0.25 gram of lime melts to a thicker mass, more brittle than the rosin alone. If the amount of lime is increased to 0.50 gram the brittleness is very much increased. Experiments made on Illinois No. 6 B coal, with varying proportions of lime and rosin, gave the following results:

Results of briquetting Illinois No. 6 B coal^a with varying proportions of rosin and lime.

		Percentage of rosin used.			
		2.	4.	6.	8.
First series:					
Lime added.....	gram..	0.033	0.067	0.1	0.133
Grade of coherence ^b		2	3	3½	3½
Second series:					
Lime added.....	gram..	0.066	0.134	0.2	0.266
Grade of coherence.....		2	2½	3	3

^a Bituminous coal from Coffeen, Montgomery County. For description, analysis, and tests see Bull. U. S. Geol. Survey No. 290, 1906.

^b See p. 22.

As 20 grams of coal were used the lime added in the first series was just sufficient to react with the rosin. The increase of lime appears from the above results to be detrimental, and the experiments were therefore not carried further. It appears that 6 per cent of rosin will be necessary to produce a satisfactory briquet with most coals, and inasmuch as rosin is now worth about \$29 per ton its use as a binder is unprofitable. Nor is it likely that it will again become cheap enough to permit its use as a binder, either alone or in combination with other materials, such as tar.

11. *Pitch*.—Owing to fluctuations in the price of rosin, pitch, which is a mixture of rosin and tar, is variable in cost. In 1905 a good grade of navy pitch was quoted at about \$35 per ton in St. Louis. The sample of pitch tested was of this grade. For the results of the tests made see table on pages 51-52.

Only 3 or 4 per cent of this pitch is necessary to produce a satisfactory briquet. The briquets stood the weather well and, except those made with the lignites, proved satisfactory in the fire.

The improvement of rosin as a binder by the addition of tar might have been predicted from the principles laid down, for rosin alone is too brittle to produce a tough briquet with a low percentage of binder,

and thinning the rosin with a heavy oil, such as tar, thus making it less brittle, would doubtless be advantageous. However, even where only 3 per cent of pitch is necessary to produce a satisfactory briquet its cost will probably always forbid its use.

12. *Pine-wood tar*.—No accurate data as to the amount of tar produced in the United States could be obtained. The census of 1900 reported 84 wood-distillation plants, but these were mostly using hard woods. The tar produced should be from 4 to 10 per cent of the weight of the hard wood used, but no record of the output was made, the tar being mainly burned under the retorts. The number of distillation plants in the South using pine wood has been considerably increased since the census of 1900, and plants have also been erected to use fir in the northwest. Both pine and fir yield much larger percentages of tar than the hard woods, and it may be that in the future the tar obtainable from these sources will be available for briquetting plants in neighboring sections of the country. The census for 1900 showed exports of 36,535 barrels of tar and pitch, valued at \$77,082, or \$15 per ton. Pine tar is quoted at 6 to 10 cents per gallon, equivalent to \$13.80 to \$23 per ton.

In the distillation of wood various grades of oils and tars are produced, depending both on the wood used and on the manner of distillation. An examination of representative samples of these various grades was undertaken in order to determine their value for briquetting purposes and also to determine how the product could best be made suitable for such purposes.

A solid pine-tar residuum, obtained from Summerville, S. C., was designated 12 A. The final results of the tests made with this binder are shown in the table (pp. 51–52). All the briquets except those made of lignite behaved satisfactorily in the fire. The pitch softened at 80° to 90° C. to a very sticky mass that apparently should bind well, but some of the briquets, even with 10 and 12 per cent of the binder, were too brittle, although they were sufficiently hard. The poor results with this binder were attributed to the high percentage of carbon in the pitch and to the failure of the pitch to spread well over the grains of coal. The pitch dissolved readily in either wood-tar creosote or coal-tar creosote. The following tests were made:

Results of briquetting Arkansas and Illinois coals with varying proportions of pine-wood tar and creosote oil.

Coal.	Binder (per cent).			Grade of coherence. ^a
	Pine-wood tar 12 A.	Wood creosote oil.	Coal-tar creosote oil.	
Arkansas A.....	5	2	.....	4½
	5	.....	2	4½
Illinois No. 11 B.....	6	2	.....	4
	6	.....	2	4

^a See p. 22.

As was to be expected, these briquets smoke, but they stand up satisfactorily in the fire. The experiments show the improvement which may be made by thinning a pitch to the proper consistency. This holds also for coal-tar pitches, as will be seen later.

The pitch here discussed is a waste product, but being produced at only a few plants is not available in quantity.

A sample of very thick pine-wood tar, obtained from Cheraw, S. C., was designated 12 B. Its flowing point was 45° C. and only 3 per cent was volatile below 270° C., the volatile portion being mostly water. This tar had a density of 1.07. The results of the experiments made with it are summarized in the table (pp. 51-52).

The briquets produced some smoke, but were satisfactory in the fire except when made with lignite. They stood the weather well. This tar may prove an available binder for some briquet plants. It is obtainable at many wood-distillation plants at prices ranging from \$15 to \$20 per ton, and as only 3 to 4 per cent is necessary to produce a satisfactory briquet with most coals the binder would range in price from 45 to 80 cents per ton of briquets produced.

Another sample, of a slightly more mobile tar than 12 B, obtained from the same plant, was designated 12 C. Its flowing point was 42° C. and its density 1.05. About 14 per cent of this tar distilled below 270° C. The results of the experiments with it are given in the table (pp. 51-52). This tar is obtainable from any of the wood-distillation plants that could furnish tar like the sample 12 B, and would command about the same price. It contains a little more of the low-boiling oils—that is, those distilling below 270° C.—than sample 12 B, and requires about 1 per cent more of the tar to produce a satisfactory briquet.

A sample of pine tar obtained at St. Louis, Mo., was designated 12 D. It was liquid at 20° C. and had a density of 1.14. On distillation about 10 per cent came off below 200° C. and 25 per cent below 270° C. The following experiments were tried:

Results of briquetting Illinois No. 6 B coal with binder 12 D.

Percentage of binder.	Grade of coherence. ^a
2	3
4	3
6	3
8	3
12	4

^a See p. 22.

The tar was evidently too liquid to produce satisfactory briquets. The residue left after distillation at 270° C. was then tested and gave a satisfactory briquet with Illinois No. 6 B coal when only 4 per cent of binder was used.

Another sample of pine-wood tar, obtained from a wood-distillation plant at Dunbar, S. C., was designated 12 E. It was found that about 5 per cent of this tar would produce a satisfactory briquet with Illinois No. 6 B coal.

Another sample of pine-wood creosote, obtained from Cheraw, S. C., was designated 12 F. This sample was liquid at 20° C. and had a density of 1.12. On distillation about 20 per cent by volume came off below 112° C., the distillate being mostly water, and 21 per cent more came off below 270° C. At 310° C. the residue swelled up and frothed over. The briquets made with this binder were not satisfactory, the reason being that the creosote was so thin that the briquets were easily crushed. They smoked in the fire, gave off the odor of creosote, and did not stand up well. The residuum left after the distillation of the creosote had been carried to 270° C. was tested with Illinois No. 6 B coal, the coherence being 3 and 4 with 6 and 8 per cent of binder, respectively.

A sample of pine-wood creosote, obtained from a plant at Dunbar, S. C., designated 12 G, was not tested, being similar to 12 F, with which no satisfactory results could be obtained. Another sample of turpentine oil obtained from the same plant, designated 12 H, was evidently of no value for briquetting purposes.

13. *Hard-wood tar*.—The sample of hard-wood tar examined was a rather thin liquid even at the ordinary temperature, and could not therefore make a sufficiently hard briquet. It had a density of 1.10. The following tests were made:

Results of briquetting Illinois No. 6 B coal with hard-wood tar.

Percent- age of binder.	Grade of coher- ence. ^a
2	2
4	2
6	3
8	3
12	3½

^a See p. 22.

On distillation below 112° C. the tar gave off 8 per cent of water; from 112° to 270° C. it yielded 44 per cent more of a light oil and of reddish paraffin oils. On testing the residue a satisfactory briquet was obtained with Illinois No. 6 B coal when 8 per cent was used as a binder. It is concluded, therefore, that the residue left from hard-wood tar after distillation to 270° C., where it is obtainable, could be used advantageously for briquetting.

14. *Fir tar*.—The sample of fir tar tested was obtained from a wood-distillation plant in the State of Washington. On distillation the tar gave off 8 per cent below 270° C. The results of the tests

are shown in the table (p. 51). As will be seen, the tar produces satisfactory briquets when 6 per cent is used.

Concerning the use of wood tar in general for briquetting, the conclusions to be drawn are that the distillation of the tar should in general be carried to 270° C., and the residue, which will be either a thick tar or a soft pitch, should be used. The briquetting qualities of a tar thus prepared will vary considerably with the source of the tar. Pine tar is best, about 4 per cent being required; fir tar comes next, about 6 per cent being required; and lastly, hard-wood tar, about 8 per cent being required to produce a satisfactory briquet. The work has not been extended to a sufficient number of samples of tar to make the above conclusions as regards the percentage of each tar required absolutely certain, but the percentages given will serve as the basis for a rough estimate of the cost of wood tar as a binder. In some localities this product might compete successfully with other binders.

15. *Wood pulp*.—The claim has been made that cellulose, which is the main constituent of prepared wood pulp, has binding properties, but a few experiments point to the conclusion that its use is wholly impracticable. Possibly the term was confused with lignocellulose, the lignone groups affording the main constituents of the sulphite liquor discussed in the next section.

16. *Sulphite liquor*.—In the manufacture of paper, wood pulp is treated with sulphurous acid to remove certain lignone groups, which combine with the SO_3H and are then removed in the waste water, in which they are soluble. This waste liquor, amounting to ten or twelve times as much as the cellulose fiber produced, yields on evaporation an average of 9 to 10 per cent of solid residues. Roughly, therefore, the amount of this solid waste material is equal to the amount of cellulose obtained. According to the United States Census report for 1900 the amount of sulphite fiber produced was 416,037 tons, and the estimate indicates that there was an equal production of the waste lignone complex.

Not only is this liquor a true waste material, finding at present no market, but its production is a great nuisance, for it very seriously pollutes the streams on which the mills are situated and gives rise to much trouble. Its cost, therefore, would be represented solely by the cost of getting rid of the excess of water and by the freight to the briquetting plant. The water could be removed by evaporation, during which process the complex groups are to some extent broken down, sulphur and sulphur compounds being formed and some of them escaping. Of the solid residue left from evaporation 20 per cent is inorganic material and 80 per cent is organic. An ultimate

analysis of the lignone complex groups shows, according to Cross and Bevan, carbon, 50.22 to 56.27 per cent; hydrogen, 5.22 to 5.87 per cent; sulphur, 5.52 to 8.80 per cent.

Efforts have been made by various investigators to separate the lignone complex groups from the water by precipitation instead of by evaporation. It is possible that some process of settling and filtration may recover the desired gummy residues without going to the expense of evaporating the water, but the processes so far devised are as yet unsuccessful on a commercial scale.

The sample of sulphite liquor examined was obtained from Detroit, Mich. On evaporation it showed a dry residue of 11.8 per cent. This residue, of course, does not melt but chars and decomposes if heated to a high temperature. Before evaporating quite to dryness the residue is a very sticky, gummy mass, easily soluble again in water. The original liquor was evaporated to about one-third of its bulk and when in this condition was used in the following tests:

Results of briquetting California lignite^a and Illinois coal with sulphite liquor.

Percent- age of binder.	Grade of coherence. ^b	
	Califor- nia No. 1.	Illinois No. 6 B.
2	.....	2
4	.....	2½
6	.....	3
8	.....	3½
10	3½	4
12	4	4½

^a Lignite from Tesla, Alameda County. For description, analysis, and tests see Bull. U. S. Geol. Survey No. 290, 1906.

^b See p. 22.

The briquets from Illinois No. 6 B coal, with 10 per cent binder, and from California No. 1, with either 10 or 12 per cent binder, were satisfactory in the fire. The briquets made from the California lignite show the good effect of using a binder which does not volatilize or melt, for this coal is one of the most difficult of all the coals with which to obtain satisfactory results in the fire. In water, of course, the briquets will go to pieces rapidly.

It must be remembered that the above percentages of binder refer not to the dry residue from the sulphite liquor, but to the liquor itself when concentrated only to one-third of its bulk. To compare the results with the dry material the percentages must be divided by three. In other words, we have from the paper mills each year 1,200,000 tons of waste material which will produce coherent briquets when 10 to 12 per cent of it is used as a binder. The drawback to its use is the fact that the briquets are not waterproof, and a few

preliminary experiments were made in an endeavor to overcome this difficulty, with the following results:

Results of briquetting California lignite and Illinois coal with varying proportions of sulphite liquor and other binders.

Coal.	Binder (per cent).				Grade of coher- ence. ^a	Fire test.	Water test.
	Sul- phite liquor.	Waterproofing constituent.					
		Material.	Amount.				
California No. 1 (lignite)	{ 8	Pitch 39	4	4	Fair.		
	{ 8	do.	8	4	O. K.	Fair.	
	{ 6	Coal-tar creosote	4	3½	O. K.		
Illinois No. 6 B	{ 6	Asphalt tar.	4	4	O. K.	Fair.	
	{ 6	Pitch 39	4	4	O. K.	Fair.	

^a See p. 22.

These experiments indicate that oils and pitches mixed with the sulphite liquor will render the briquet more or less waterproof, depending on the extent and character of the added constituent. The whole problem is an important and promising one and deserves further investigation.

SUGAR-FACTORY RESIDUES.

17. *Beet pulp*.—Several samples of beet pulp (a waste product) were examined and carefully tested in the hope that they might contain sufficient starchy or sugary material to serve as a binder. The results showed that the pulp could be of no use whatever for this purpose. Details of the tests need not therefore be given.

18. *Lime cake*.—The sample of lime cake examined proved to be practically pure calcium carbonate, which could be of no possible use in briquetting.

19 and 20. *Beet-sugar molasses and cane-sugar molasses*.—The binding power of molasses is said to be due to pectin, which is a body closely related to mucilage and has the constitution of a typical lignocellulose. To a less extent the binding power is due to sugar. Molasses contains only about 10 per cent of ash. From 1 to 1.5 per cent of molasses in water is said to be sufficient for binding, but the experiments do not verify the statement. Three samples of beet-sugar molasses were examined—19 A, 19 B, and 19 C. Samples 20 A and 20 B were cane-sugar molasses. The moisture and ash were determined as follows:

Moisture and ash in beet-sugar and cane-sugar molasses.

	Beet-sugar samples.			Cane-sugar samples.	
	19 A.	19 B.	19 C.	20 A.	20 B.
Moisture.....per cent..	12.5	13.8	21.8	27.3	27.5
Ash.....do....	8.1	10.1	9.9	6.3	5.7

Tests in briquetting Illinois No. 6 B coal with these samples gave the following results:

Results of briquetting Illinois No. 6 B coal with varying percentages of beet-sugar and cane-sugar molasses.

Percentage of binder.	Grade of coherence. ^a				
	19 A.	19 B.	19 C.	20 A.	20 B.
2	3	2			
4	3	3	2	2½	2
6	3	3	3	3	3
8	3	3	3	3	3
12	3	3	3	3	3

^a See p. 22.

The coherence of the briquets did not seem to be increased by using more than 6 per cent of molasses. The failure to obtain good briquets with smaller percentages or to obtain satisfactory briquets even when the higher percentages were used is hard to explain. Heating the briquets to a higher temperature, even to 150° or 160° C., did not seem to improve them. Their behavior in the fire could not be regarded as very satisfactory. In water they fell to pieces.

Some experiments were made with lime and molasses and also some attempts to waterproof these briquets, but no very satisfactory results were obtained. The use of molasses as a binder needs further investigation before it is finally classed as being of no use for briquetting, but so far it would seem to be without commercial value for this purpose.

The census report for 1900 showed that there were 3,551,856 gallons of this molasses produced, valued at \$25,102 for the portion sold. Much of it went to waste.

STARCH.

21. *Cornstarch*.—In the tests of cornstarch it was first necessary to determine if heating the starch with water to a paste, thus forming dextrin, before mixing it with the coal was essential, or if the change of starch into dextrin would take place as well when the starch was first mixed with the coal and the mixture then moistened and heated. The experiments showed that the latter procedure was fully as effective. Starch was tested more particularly with the lignites, because it does not evaporate before burning, and hence would hold the lignite together in the fire. The results of the tests are shown in the table (pp. 51–52). In all the tests the behavior of the briquets in the fire was far more satisfactory than if pitch or a similar binder had been used. Starch possesses the advantage over such binders that it adds no smoke-producing material to the coal.

In water these small starch briquets fell to pieces in a few minutes, and the next endeavor was to waterproof them. Many attempts were

made to accomplish this end by immersion in oil. The experiments indicated that any oil would waterproof the briquet when externally applied, but asphalt tar, which was the thickest oil tested, gave the best results. It is doubtful if external waterproofing with a thick oil would ever be commercially successful, owing to the cost and difficulty of manipulation, but a thin oil, such as crude petroleum, might answer. At any rate, laboratory tests with small briquets can not finally decide the point, and the experiments should be conducted on a larger scale.

An endeavor was also made to waterproof by mixing the coal and starch with some of the oils before briquetting. For this purpose Hoffman's petroleum, Kansas crude oil, coal-tar creosote, asphalt tar, water-gas tar pitch, coal-tar pitch, and hard-wood tar were used under varying conditions and with varying percentages both of the starch and of the oils. The experiments indicate that the presence of crude oil or tarry liquids is detrimental to the action of the starch, both as to coherence and in the fire. But the binding power of the starch, though somewhat diminished, was nevertheless still very great, and it is probable that a briquet with 1 per cent of starch and 8 per cent of a heavy crude oil, or a less percentage of oil residue, would prove satisfactory. It is possible that in some places such a combination might prove the cheapest and most satisfactory binder obtainable. Pitches did not seem to injure the action of the starch, but unless a small percentage of pitch is found to waterproof there would be nothing gained by the combination. The experiments made did not seem to indicate that a small percentage of pitch with starch would give satisfactory results in the weather, but this point should be tested on a larger scale.

A patent for the use of starch as a binder was issued in 1858, in England, to John Piddington. He used 36 pounds of starch and 8 per cent of water per ton of coal.

The objections to starch as a binder are that the briquets do not immediately harden, and that they will not stand exposure to the weather unless made waterproof. The advantages of starch as a binder are its cheapness, its wide availability, the fact that it introduces no smoke, and the fact that, being nonvolatile, it holds the coal together well.

As shown by the census report for 1900 the amount of starch produced in the United States during that year was 297,803,139 pounds. Of this amount 247,051,744 pounds was made from corn as raw material, the average price of the starch being 2.5 cents per pound. It is of course not necessary that starch to be used as a binder be pure, and a far better idea of its cost for this purpose can be obtained by considering the cost of the raw material.

The raw materials available in the United States are corn, wheat and other small grains, Irish potatoes, sweet potatoes, cassava, and spoiled products containing starch. The starch from wheat and other small grains is more expensive than that from corn. Cassava, yielding 4 to 5 tons per acre and containing about 25 per cent of starch, offers a very cheap source of starch, but in the United States it can not be grown far north of Florida.

In 1900, 231,106 tons of corn were used for the production of cornstarch, the average price paid being \$11.78 per ton. Corn contains 60 to 65 per cent of starch. The factories extracted on the average 53.4 per cent, and the cost of this starch in the crude condition is therefore \$18.85 per ton. The only preparation necessary would be fine grinding.

The price of raw cornstarch may be estimated at \$20 per ton, based on the census report for 1900, and inasmuch as only 0.5 to 1 per cent of this material is required to make a coherent briquet, it follows that the cost of starch binder of this kind per ton would be only 10 to 20 cents. The briquets would not stand rain, but would prove perfect if kept under cover. It seems that starch briquets, only slightly waterproofed, might be used during the dry season in certain sections of the West. If more thoroughly waterproofed with heavy crude petroleum oils they might be generally used. The crude petroleum would increase the fuel value of the briquet almost sufficiently to pay for itself. It seems, therefore, that further experiments with starch on a larger scale are desirable.

22. *Potato starch.*—Properly chosen varieties of the sweet potato contain about 22 per cent of starch and the yield per acre is large. Small, unmarketable potatoes may be used. The sweet potato is available in many parts of the United States.

The Irish potato is widely distributed, and starch factories consumed 118,000 tons in 1900, paying an average of \$5.90 per ton and obtaining an average of 14.3 per cent of starch. As a rule only unmarketable potatoes were used and this accounts for the low percentage of starch obtained, the average yield of Irish potatoes being 18.2 per cent of starch, and some varieties giving as high as 25 per cent. On the basis of 18 per cent available starch, the raw starch obtained from this source is worth \$32.75 per ton.

Usually, therefore, starch obtained from potatoes would be more expensive than that obtained from corn. A number of tests were made to see if the action of the two starches is similar. No difference in the coherence of the briquet or in its behavior in the water or in the fire was detected.

SLAUGHTER-HOUSE REFUSE.

Slaughter-house refuse, which is now largely made into glue, has been so often suggested as a binder that its cost was investigated. The census of 1900 showed that 34,750 tons of glue were produced, valued at \$155 per ton. The price is therefore prohibitive and no experiments were made with this material.

TARS AND PITCHES FROM COAL.

Preliminary considerations.—The work done at the briquetting plant under the direction of Dr. J. H. Pratt had shown that there was great variation in the value of various coal-tar pitches for briquetting purposes. That work had also shown that coal-tar pitch would be one of the most important binders to be considered. An endeavor was made, therefore, to study the various grades of coal tar and the pitches therefrom, with the idea of improving the pitches and of establishing some method of examination which might reveal their value without the necessity of an actual briquetting trial.

The total production of coal tar in the United States in 1903 was 62,964,393 gallons, valued at \$0.0349 per gallon, or \$7.27 per ton.

On distillation coal tar is divided into several fractions which are more or less clearly defined. By further distillation these fractions are separated more completely and find their way to the market as illuminating oils, naphtha, creosote, etc. They consist of a very large number of chemical compounds. The manner in which coal tar is fractionated varies at different works, but as illustrative, it may be said that the ammoniacal liquor distils first, then the first light oils, boiling below 110° C. The second light oils come off at 110° to 170° C., the carbolic oils at 170° to 225°, the creosote oils at 225° to 270°, the anthracene oils at 270° to 360°, and lastly the pitch is left behind as a residue.

None of the oils coming off below 270° C. are useful in briquetting. The anthracene oils, which consist of a large number of different compounds, should not, however, be entirely distilled from the pitch if it is desired to use the pitch for briquetting. Nearly all the various constituents of both the pitch and the anthracene oils except the free carbon are soluble in carbon disulphide. Constam and Rougeot^a examined 33 pitches obtained from various sources, and found the amount of carbon-disulphide extract to range from 60.43 to 91.22 per cent and to average 76.3 per cent. They also found the value of the pitch for briquetting purposes to be proportional to the amount of carbon-disulphide extract. The results obtained by the writer lead to the same conclusion, except that the free carbon (that is, the insoluble portion) is believed to be not only inert but detrimental to

^a Zeitschr. f. angew. Chemie, vol. 17, no. 26.

the pitch, indicating that the increase in the value of a pitch for briquetting purposes is somewhat greater proportionally than the increase in the percentage of extract obtainable. The free carbon seems to prevent the pitch from spreading easily over the grains of coal, and owing to its very finely divided condition itself offers a very large surface for the absorption of pitch.

A pitch has no true melting point, but owing to the large number of different chemical bodies which it contains, softens only very gradually. This softening point of the pitch has a marked influence on its use in briquetting, for the pitch must either be so brittle that it can be broken finely and mixed with the coal as a solid, or it must be melted and distributed as a liquid. Many pitches soften at so high a temperature that they can not be efficiently used except by heating above 100° C. The pitch must therefore be adapted to the briquetting machine in which it is to be used. Many methods of determining the softening point of a pitch have been suggested, but most of them are either too troublesome for practical use or not accurate. In the experiments here recorded the flowing point of the pitch was used as an index of the temperature at which it softened. This point was determined by placing about 3 cubic centimeters in the bottom of a test tube one-half inch in diameter and inserting the tube in a bath. The temperature of the bath was raised until, on taking out the tube and inverting it, the pitch flowed 1 inch down the tube in fifteen seconds.

In ascertaining the value or suitability of a given pitch or tar for briquetting purposes three determinations are necessary:

1. The pitch or tar is distilled and all oils coming off below 270° C. are rejected as being of no value in briquetting.
2. The flowing point of the portion to be used in briquetting is determined. This should generally be not less than 70° C.
3. The pitch is extracted with carbon disulphide. The smaller the amount of residual carbon the more satisfactory the pitch.

It should be borne in mind that the higher the flowing point of the pitch the more satisfactory it will prove in the fire when used with coals that do not cake readily. If the pitch has too high a flowing point to be workable with the briquet machine at hand, it could be softened by the addition of a high-boiling coal-tar oil (above 270° C.) or of very soft pitch. Coal-tar creosote could be used, but its boiling point is too low to make its use in all respects satisfactory.

23. *Blast-furnace tar*.—As it was impossible to learn whether blast-furnace tar and the similar material known as shale tar are produced in the United States, no experiments were made with them.

24. *Producer-gas tar*.—Two samples of producer-gas tar were examined. The first, designated 24 C, after pouring off the water, gave on distillation, water, 30 per cent; oils below 270° C., none;

oils at 270 to 330° C., 6 per cent. From 330° the thermometer jumped suddenly to 370° and the distillation was stopped. The residue gave with Illinois No. 4 coal a satisfactory briquet when only 4 per cent was used as a binder.

The next sample, designated 24 D, was tested after boiling off the water. The result showed a satisfactory briquet with Arkansas No. 7 A coal when 4 per cent was used, but a larger percentage is necessary with most other coals and probably 8 per cent would be necessary for most lignites.

The tar obtained, when freed from water only, is rather too liquid to produce the best quality of briquet. But the removal of only about 6 per cent of oils raises the flowing point of the tar to about 70° C. and the residue appears, as above seen, to be excellently fitted for briquetting purposes. The amount of carbon-disulphide extract obtainable from the residue was not determined. It should not be large, for the temperature at which the tar is made is comparatively low. This is probably the cause of the superior binding power of the pitch.

The amount of this tar obtainable and its market value are questions for future determination.

25. *Illuminating-gas tar*.—About 25 per cent of the illuminating gas produced in the United States is made from coal, and the tar resulting from the process amounts to about 5 per cent of the coal coked. The census report for 1900 gives the production for 1899 as 67,094 tons. In 1903, 61.4 per cent of the coal tar made was produced in gas works. The average value of this tar as distinct from other coal tars is not obtainable, and \$7.27 per ton, the average value of all coal tars for 1903, is therefore accepted as approximately correct for gas tar.

This tar is too liquid to produce good briquets. The oils coming off below 270° C. should be disposed of. The residue, equaling 70 per cent of the total, would cost \$10.40 per ton, if the sale of the low-boiling oils could be made to pay the expense of the distillation and the profit thereon.

Pitches 28 A, 28 B, 28 C, 28 D, 28 E, 28 F, and 28 I, obtained from this tar, were examined, and the percentages determined as necessary to make satisfactory briquets are shown in the table (pp. 51-52).

26. *By-product coke-oven tar*.—In 1903, 38.6 per cent of the total coal tar produced (24,296,536 gallons) was produced in by-product coke ovens. The census report for 1900 shows that in 1899 only 3.33 per cent of the total coal coked was coked in by-product ovens. Consequently the amount of coal tar from this source could be enormously increased.

This tar is obtained by distillation at a high temperature, and therefore contains more fixed carbon than tar from illuminating-gas

plants. About 60 per cent of the tar from an Otto-Hoffman oven is pitch.

The tar is too liquid to be used directly for briquetting. The results with pitches 28 G and 28 H, made from coke-oven tar, are shown in the general table (p. 51).

27. *Coal-tar creosote*.—The principles governing the use of binders make it appear useless to test coal-tar creosote alone. It is too thin a liquid to make coherent briquets and of too low a boiling point to give satisfactory results in the fire. This creosote could be used to thin a pitch whose boiling point is too high, when such use is advantageous. It could also be used to waterproof a binder that would not stand the weather; but this could be done as well with a crude oil of low specific gravity, and the cost would be less. Coal-tar creosote is worth about 6 cents per gallon.

28. *Coal-tar pitches*.—The pitch designated 28 A was obtained by Dr. J. H. Pratt, who called it pitch C in his report.^a This pitch flowed at 100° C., and the behavior of the briquets in the fire was satisfactory.

The pitch designated 28 B was obtained through Dr. Pratt and was by him designated, in his report, pitch D. This pitch had a flowing point of 127° C. It was used in making a very large number of tests on the comparative action of different coals with the same binder.

The pitch designated 28 C was used to briquet 50 tons of Arkansas semianthracite slack, about 6.5 per cent being used. This pitch had a flowing point of 100° C. It proved too soft for use with a pitch cracker on a summer day.

The pitch designated 28 D was used to briquet 200 tons of Arkansas semianthracite slack, about 6.5 per cent being used. This pitch had a flowing point of 120° C. and was sufficiently brittle for use on the hottest day. It gave a carbon-disulphide extract of 67.75 per cent.

The pitch designated 28 E had a flowing point of 100° C.

The pitch designated 28 F was very soft, having a flowing point of 68° C., and did not prove as efficient a binder as its appearance indicated. No further examination was made to determine the cause of the trouble.

The pitch designated 28 G was a soft coke-oven pitch obtained from tar produced in the Semet-Solvay process. It had a flowing point of 95° C. and yielded about 86 per cent of carbon-disulphide extract.

The pitch designated 28 H was a harder coke-oven pitch from the same source as 28 G. It had a flowing point of 100° C. and gave 81.50 per cent of carbon-disulphide extract. The briquets were possibly a little stronger than those made with the soft coke-oven pitch.

^a Preliminary report on the operations of the coal-testing plant of the United States Geological Survey at the Louisiana Purchase Exposition, St. Louis, Mo., 1904; Bull. U. S. Geol. Survey No. 261, 1905, p. 134.

The pitch designated 28 I was received through Dr. Pratt, who called it pitch X in his report.^a It had a flowing point of 190° C., being very hard and brittle. The carbon-disulphide extract was 63.2 per cent. A large number of tests were made with this pitch when determining the qualities of binders in general in order to learn why this grade was so poor a binder. This seemed to be due to two causes—(1) the large amount of contained free carbon (36.8 per cent), and (2) the high softening point. At 100° C. the binder did not melt sufficiently to spread over the grains of coal to the best advantage.

To test this latter point the pitch was mixed with wood creosote 12 F, which did not itself possess sufficient binding power. Two hundred grams of pitch was mixed with 100 grams of the wood creosote and heated with stirring until thoroughly mixed. The resultant pitch, which was brittle enough to be pulverized if kept cool, was then tried with a number of coals and compared with the original pitch. The results from this mixture, designated 28 J, are shown in the table (pp. 51–52). It will be noted that in all the tests 4 per cent more of the original pitch than of the mixture was required, thus confirming the diagnosis of the trouble.

None of the coal-tar pitches gave coherent briquets with less than 6 per cent, and with many of them 7 or 8 per cent was required. The reason why a coal-tar pitch will not briquet if less than 6 per cent is used is that it contains a comparatively large amount of carbon. The residue from producer-gas tar made satisfactory briquets with 4 per cent, and this result was doubtless due to the fact that such tar contains little free carbon.

The cost of coal-tar pitch per ton may be taken as \$11; therefore the cost of the binder per ton of briquets produced ranges from 66 to 88 cents. The briquets when properly made will stand exposure to the weather well. They will stand up satisfactorily in the fire if the coals cake at all readily. With noncaking coals the briquets would not prove satisfactory in the fire. This binder does not cause an undue amount of smoke.

NATURAL ASPHALTS.

Asphalts grade almost imperceptibly into heavy, thick petroleum oils. The designations used by Eldridge^b have been followed in this discussion. Wurtzilite, nigrite, ozocerite, and grahamite occur in the United States, but not in deposits profitable to mine.

^a Preliminary report on the operations of the coal-testing plant of the United States Geological Survey at the Louisiana Purchase Exposition, St. Louis, Mo., 1904; Bull. U. S. Geol. Survey No. 261, 1905, p. 134.

^b Eldridge, G. H., Origin and distribution of asphalt and bituminous rock deposits in the United States: Bull. U. S. Geol. Survey No. 213, 1903, pp. 296–305.

30. *Impsonite*.—Impsonite, sometimes called grahamite, is found in Oklahoma. It softens at a high temperature, but does not melt. In carbon disulphide 35 per cent or more is dissolved.

The sample tested was obtained through Dr. Pratt and was designated B 4 in his report.^a This was tested with a lignite, as its only possible use in briquetting was considered to be to mix with a non-caking coal in rather large percentage. From 20 to 30 per cent was found to be required to hold a California lignite together in the fire. Even though the material is very cheap, the large percentage required prohibits its commercial use.

31. *Gilsonite*.—It is estimated by Eldridge that 32,000,000 tons of the asphalt known as gilsonite are now in sight in the extensive deposits that occur in Utah. He further states that the cost to mine does not exceed \$1.75 per ton. The material has to be hauled a long distance to a railroad, and the present price in St. Louis is about \$35 per ton. Gilsonite has a brilliant luster, burns and acts like sealing wax, and is entirely soluble in carbon disulphide. Two samples were tested.

The sample designated 31 A was black, with a brilliant luster, and flowed at about 250° C. In testing, the finely powdered material was mixed dry with the coal and heated far above 100° C. As shown in the table (p. 52) it gave a good briquet when 4 per cent was used.

The sample designated 31 B was black, with a less brilliant luster. When its flowing point was being determined it frothed out of the tube. It gave a briquet of satisfactory coherence when 6 per cent was used as a binder. The briquets are also satisfactory in the fire; and, owing to the high softening point of the binder, it would be very useful with noncaking coals. At its present price of \$35 per ton, however, even 4 per cent of this binder is out of the question.

32. *Maltha*.—Small deposits of maltha, a liquid asphalt, occur in Oklahoma, Mexico, California, and Texas. In 1903 the only production reported to the Geological Survey was 58 tons from Texas, valued at \$19.83 per ton.

The sample tested was obtained through Dr. Pratt and was called by him "liquid Austin asphalt." A satisfactory briquet was produced with 3 to 3½ per cent of binder. Attention is called to the fact that when as much as 8 per cent of this binder is used the briquet grows weaker instead of stronger. This is due to the low flowing point of maltha, 58° C., which causes the briquet to crush easily if an excess is used. In the fire the binder would give satisfactory results only when used with coals that cake very easily.

^a Preliminary report on the operations of the coal-testing plant of the United States Geological Survey at the Louisiana Purchase Exposition, St. Louis, Mo., 1904; Bull. U. S. Geol. Survey No. 261, 1905, p. 134.

The cost of this binder, 3 per cent being used, would be 60 cents per ton of briquets produced. With some coals a larger percentage would be necessary.

33 and 34. *Refined Trinidad asphalt and refined Bermudez asphalt.*—Considerable quantities of crude Trinidad and Bermudez asphalts are annually imported. In 1903 the imports of the former amounted to 129,133 tons, valued at \$367,003; and of the latter 9,898 tons, valued at \$48,218.

The cans in which samples were furnished for these experiments were not marked and complete identification was impossible. The softer of the two samples flowed at 115° C. and could not be powdered. It gave a satisfactory briquet when 6 per cent was used with Illinois No. 11 C (4) coal. The harder sample could be powdered, flowed at 180° C., and on testing showed a briquet that was hardly satisfactory when 8 per cent of the binder was used with Illinois No. 11 C (4) coal. If the binder had been superheated better results could probably have been obtained.

These asphalts apparently could not compete with coal-tar pitches as binders.

35. *Hard and refined asphalts.*—Bituminous sandstones, limestones, or shales occur in several States in deposits of considerable extent. These are mined, but usually the rock is used as a constituent of paving mixtures and the bitumen is not extracted. Attempts have been made to refine this rock either by distillation or by extracting the bitumen with a solvent, such as naphtha. The process does not seem to have been very successful commercially. The only production reported is 6,400 tons from California, with a value per ton of \$21.87; and 877 tons from Indian Territory, with a value per ton of \$17.61. No samples could be obtained, and the product is probably not now on the market.

PETROLEUM PRODUCTS.

36. *Crude oil.*—Unless they are of the consistency of maltha, crude oils are not suitable for binders, being too liquid. They might be used to advantage in waterproofing briquets made with starch, sulphite liquor, or molasses.

37. *Petroleum residuum.*—There are many grades of petroleum residuum depending on the base of the crude oil (that is, whether the oil has an asphalt base, or a paraffin base, or an asphalt and paraffin base), on the temperature at which the distillation is stopped, and on the amount of cracking to which the oil is subjected during the distillation.

In 1903, 46,000 tons of asphaltic residue, with an average value of \$11.30 per ton, were produced from petroleum in California; and

2,100 tons, valued at \$14.16 per ton, were produced in Texas. If 4 per cent of this material were used as a binder, the cost per ton of briquets produced would be 45 to 55 cents per ton, making this binder one of the cheapest to be had near the oil fields, when the oil contains an asphalt base. Even less than 4 per cent could be used with some coals. For the best results, the asphalt residue should flow at 90° to 100° C.

Six samples of asphalts were examined. The sample designated 37 A was shown by test to flow at 100° C., and 99.38 per cent was soluble in carbon disulphide. The tests showed that except with the lignites, 3 to 4 per cent of this asphalt would give a satisfactory briquet. With caking coals it is satisfactory in the fire.

Another sample was designated 37 B. With most coals 3 to 4 per cent of this asphalt would be required to produce satisfactory briquets.

The sample designated 37 C was received through Dr. Pratt from Caspar, Wyo., and by him was designated B 6 in his report.^a It flowed at 95° C., and gave a carbon-disulphide extract of 99.88 per cent. A satisfactory briquet was made with 4 per cent of this binder.

The sample designated 37 D was received from Texas, and was designated B 3 in Dr. Pratt's report.^a It flowed at 140° C., and with most coals about 6 per cent would be required to produce a satisfactory briquet.

The sample designated 37 E, a California asphalt of grade B, was designated B 1 by Dr. Pratt.^a It did not soften sufficiently at 100° C., but if superheated a satisfactory briquet could be obtained with 8 per cent as binder.

The sample designated 37 F, a Texas asphalt, was designated B 2 by Dr. Pratt.^a It did not soften sufficiently at 100° C. When superheated it gave a satisfactory briquet with Illinois No. 4 coal, 6 per cent of binder being used.

38. *Water-gas tar*.—The census report states that 75 per cent of the illuminating gas produced in the United States in 1899 was water gas. Petroleum oil is used in enriching this gas and is partly decomposed in the process, resulting in the formation of water-gas tar, of which 48,714,324 gallons were produced in 1899. With an average density of 1.1, this would be equivalent to 222,868 tons of tar. The tar itself is too liquid for use, but a pitch made from it was examined, as shown in the next paragraph.

39. *Water-gas tar pitch*.—The sample of water-gas tar pitch furnished to Dr. Pratt was by him designated pitch H.^a It flows at 92° C., and with some of the coals 5 per cent proved sufficient to produce excellent briquets. The carbon-disulphide extract was 88.10 per cent. With caking coals the briquets are satisfactory in the fire. This pitch is worth somewhat less than coal-tar pitch, its value being

^a Preliminary report on the operations of the coal-testing plant of the United States Geological Survey at the Louisiana Purchase Exposition, St. Louis, Mo., 1904; Bull. U. S. Geol. Survey No. 261, 1905, p. 134.

given approximately as \$10 per ton. The cost of the binder per ton of briquets produced would therefore be about 50 cents, effecting a saving of at least 20 cents per ton over the use of ordinary coal-tar pitch.

40. *Wax tailings*.—A product known as wax tailings was received by Dr. Pratt. It is soft at ordinary temperatures and pulls into long threads. It melts to a thin liquid at about 70° C. As low as 3 per cent gives briquets of satisfactory coherence and these are also satisfactory in the fire if the coal cakes readily. The briquets could not be subjected to any pressure in the fire, and would yield to pressure if placed in a warm place. It is doubtful if they could be piled in a very hot sun. The yield of this product is said to be moderate in amount. The value is 6 cents per gallon, or about \$15 per ton, and the cost of this binder would therefore be 45 to 60 cents per ton of briquets produced.

41. *Acid sludge*.—Tests of a sample of acid sludge showed that 10 to 12 per cent was necessary to make a coherent briquet. This material was distinctly acid with sulphuric acid. Its value could not be learned and therefore no further experiments were tried with it.

42. *Asphalt tar*.—The product known as asphalt tar, as obtained by Dr. Pratt, was a rather thin liquid which poured readily and produced briquets that would crush easily and would not stand up satisfactorily in the fire. This tar, if its price permitted, might be used for waterproofing briquets made with soluble binders, as starch, sulphite liquor, or molasses.

43. *Pintsch gas tar*.—Pintsch gas tar, produced by the heating of petroleum oil in iron retorts to a high temperature, is obtained as a thin emulsion in water, being too thin for use as a binder. As it is produced only in very small amounts in the United States, its further examination was deemed inadvisable.

44. *Pittsburg flux*.—The substance known as Pittsburg flux is made by heating petroleum residuum with sulphur. The sample tested was tough and sticky, would cut easily, but would not pull into threads. It melted to a thin liquid at about 195° C. In testing it was mixed with Illinois No. 11 C (4) coal and heated far above 100° C. It produced a satisfactory briquet when 8 per cent was used.

ADDITIONAL EXPERIMENTS WITH MIXTURES.

All the briquets made with inorganic binders were brittle, though very hard. Experiment had shown that when brittle pitches, etc., were used, the briquets became less brittle if a thinner pitch or oil was added. Therefore an attempt was made to improve these briquets by the addition of organic binders. For this purpose coal-tar creosote (27), asphalt tar (42), and water-gas tar pitch (39) were chosen. The results are shown in the following table:

Results of briquetting California and Illinois coals with varying mixtures of organic and inorganic binders.

Coal.	Binder.				Grade of coher- ence. ^a
	Inorganic constituent.		Organic constituent.		
	Material.	Per cent.	Material.	Per cent.	
Illinois No. 6 B.....	Plaster of Paris.....	6	Coal-tar creosote.....	4	3
	do.....	6	Asphalt tar.....	4	4
	do.....	6	Water-gas tar pitch.....	4	4
	Portland cement.....	6	Coal-tar creosote.....	4	3
	do.....	6	Asphalt tar.....	4	3
	do.....	6	Water-gas tar pitch.....	4	4
	Magnesium oxide.....	2	Coal-tar creosote.....	4	3
	do.....	2	Asphalt tar.....	4	3
	do.....	2	Water-gas tar pitch.....	4	3
	do.....	2	do.....	8	4
California No. 1.....	Plaster of Paris.....	6	do.....	8	4
	Portland cement.....	6	do.....	8	4
	Magnesium oxide.....	3	do.....	8	4
	do.....	4	do.....	4	3

^a See p. 22.

The briquets made with Illinois coal and water-gas tar pitch were fairly good and stood up very satisfactorily in the fire. The advantage gained, however, over the use of the water-gas tar pitch alone would not be sufficient to offset the introduction of the 6 per cent of ash with the cement or the plaster of Paris, or the cost of the magnesium oxide when that material is used. The cohesive force of the briquets made with the two binders was no greater than the sum of the cohesive force obtained with each separately. The only advantage to be gained by using such mixed binders would be an added strength in the fire. Experiments with the California lignite were therefore made as above shown. The briquets were found to be considerably improved as to their behavior in the fire by the addition of the inorganic constituent of the binder. Briquets from this coal made with pitch alone fall to pieces badly in the fire. The improvement in this regard, however, is offset by the added expense and the introduction of ash, and it is therefore considered more desirable where possible to mix such noncaking coals with caking coals before briquetting. If this is not practicable then the addition of inorganic binders might be tried as a last resort. Should the inorganic binders be used, magnesium oxide and plaster of Paris will be found to give the most satisfactory results, 3 per cent of the former being equivalent to 5 to 6 per cent of the latter.

EXPERIMENTS IN BRIQUETTING WITHOUT BINDERS.

Many experiments were made in the endeavor to obtain briquets by heating the coal without binder and then pressing. It was found that if this heating was done in a clay crucible as usual, coherent briquets could not be obtained. But if the heating was done in a small nickel crucible and the pressure applied before the coal was allowed to cool, briquets having considerable coherence were often produced. If the coal cooled after it had softened or commenced to cake, a coherent briquet could not be obtained, and even on again heating the coal it would not cohere in the press. This fact has also been noted by C. C. Catlett.^a It was undoubtedly because of the necessary chilling of the heated coal in taking it out of the crucible that better results were not obtained by this method. The experiments show the necessity of heating the coal under pressure if briquets are to be made without a binder. The German presses for briquetting lignite coal without a binder, which heat the coal by friction produced in the molds, are undoubtedly based on the right principle.

RESULTS OF TESTS IN BRIQUETTING DIFFERENT COALS.

The results of the tests here reported should be interpreted in connection with the detailed discussion of each binder. Thus while binders 12 D, 13, 25, 26, etc., mentioned in the table which follows, are too liquid for use as a binder, the pitches or tarry residues left after distilling off the low-boiling oils from these binders will make excellent briquets, as has been already pointed out. It should be remembered, moreover, that the degree of fineness to which the coal is powdered, and also the temperature to which the mixture of coal and binder is heated, will affect the character of the briquet and the percentage of binder necessary to make it coherent. Doubtless an uncontrolled variation in these factors has caused individual results to vary, but probably not to such an extent as to affect any important conclusions to be drawn from the work.

Although many of the binders were tried with only one coal, the result permits the approximate prediction of the percentage of binder for any other coal in the table. It is not possible, however, to predict with the same certainty for the lignites, which show at times variations not susceptible of easy explanation.

^a Eng. and Min. Jour., vol. 71, 1901, p. 329.

Results of tests in briquetting different coals, showing percentages of binder necessary to make a satisfactory briquet.

Designation of binder.		Field designation of coals and lignites briquetted.											
Material. ^a	No.	Ar- kan- sas. 7 A 7.	Cali- for- nia. 1.	Colo- rado. 1.	Illinois.								
					4.	5.	6 B.	7 C.	7 D.	8.	9 A.	10.	11 B.
1	2	3	4	5	6	7	8	9	10	11	12	13	14
Clay.....	1	8	8				8						8
Magnesia.....	3	4					5						4
Magnesia cement ^b	4												4
Plaster of paris.....	5												12
Portland cement.....	6												12
Natural cement.....	7												14
Water glass.....	9												14
Rosin.....	10	6	6				6						6
Pitch.....	11	3	5				4						3.5
Wood-tar pitch.....	12 A	8	12				12						10
Pine-wood tars.....	12 B	3	8				4	3		5	5	4	3.5
	12 C	4	9				5	4		5	5	5	4.5
	12 E						6						
Fir tar.....	14						6						
Sulphite liquor.....	16		12				10						
Cornstarch.....	21	0.5	1	1			1						0.75
Potato starch.....	22	.5	1	1			1						.75
Producer-gas tar pitch.....	24 C				4								
Producer-gas tar.....	24 D	4											
	28 A	6					7						7
	28 B	8	16		12	8							
	28 C	6.5											
	28 D	6.5			8								
	28 E				7								
	28 F				8								
	28 G				6								
Coal-tar pitches.....	28 H				6								
	28 I	14		20			16	14		16	16	16	15
	28 J			16			12	10		12	12	11	11
	32				3								
Maltha.....	37 A	3	6				4						4
	37 C	3.5					4						4
	37 D				6								
	37 E				7								
Petroleum residuums.....	37 F				6								
Water-gas tar pitch.....	39	4.5	8		6.5		6	5	6	6.5	6.5	6	5
Wax tailings.....	40	3					4						3
Acid sludge.....	41	12	14				14						14

^a The following materials were found to be of no use as binders: Lime (2), slag cement (8), wood pulp (15), beet pulp (17), lime cake (18), and impsonite (30). Those found to be too liquid for use as binder were: Pine-wood tar (12 D), pine-wood creosote (12 F), hard-wood tar (13), illuminating-gas tar (25), by-product coke-oven tar (26), coal-tar creosote (27), crude oil (36), water-gas tar (38), asphalt tar (42), and Pintsch gas tar (43). Satisfactory briquets were not obtained from beet-sugar molasses (19) and cane-sugar molasses (20). Blast-furnace tar is not produced in the United States.

^b Contained sufficient magnesia to make 4 per cent MgO

Results of tests in briquetting different coals, showing percentages of binder necessary to make a satisfactory briquet—Continued.

[illegible]

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DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

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BULLETIN 344

THE
STRENGTH OF CONCRETE BEAMS

RESULTS OF TESTS OF 108 BEAMS
(FIRST SERIES)

MADE AT THE STRUCTURAL-MATERIALS
TESTING LABORATORIES

By RICHARD L. HUMPHREY



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THE STRENGTH OF CONCRETE BEAMS.

By RICHARD L. HUMPHREY.

INTRODUCTION.

SCOPE OF INVESTIGATIONS.

The tests of concrete beams described in this bulletin form a part of a comprehensive series of investigations undertaken by the United States Geological Survey for the purpose of determining the strength of concrete and reinforced concrete.

The work involved in these investigations consists of a study (1) of the constituent materials of concrete, (2) of its strength when molded into various structural shapes, and (3) of the methods by which its maximum strength may be developed through various forms of metallic reinforcement.

Although it is true that concrete possesses but little strength in tension and must be reinforced with metal to resist tensile stresses, it is believed that no study of concrete would be complete without a series of tests establishing its strength without reinforcement.

The tests herein reported indicate that concrete is unsuitable for use under conditions where it must resist tensile stresses, because of the small loads it will sustain and particularly because of the suddenness with which it fails, in striking contrast to the behavior of reinforced concrete, which usually shows a gradual development of cracks preceding failure.

This first series of beam tests covers 144 beams without reinforcement 8 by 11 inches in section and 13 feet long, together with the corresponding compression test pieces, consisting of cylinders 8 inches in diameter by 16 inches in length and of 6-inch cubes. Of these tests those on 108 beams of 12-foot span, with their cylinders and cubes, and those on 108 beams of variable spans, 6 to 9 feet, which were made of the larger part of the 13-foot beams after rupture, are herein reported and comprise all of this series except the 52-week tests.

An attempt has been made to bring out, if possible, the comparative value of gravel, granite, limestone, and cinders for use in concrete; the effect of age and consistency on the strength, as shown by the modulus of rupture of the long and short beams and by the ultimate strength of the cylinders and cubes; and the influence of age and consistency on the stiffness, which is indicated by the unit

elongation of the long and short beams and by the initial modulus of elasticity, as determined by tests of the cylinders.

Three consistencies—wet, medium, and damp—were somewhat arbitrarily chosen, and are described on pages 20–21 in greater detail. Tests were made at the ages of 4, 13, 26, and 52 weeks. There are, then, as indicated in the following table, but two variables—aggregate and consistency—for each age.

Outline of tests of concrete beams.

Aggregate.	Consistency.											
	4 weeks.			13 weeks.			26 weeks.			52 weeks.		
Granite.....	Wet.	Med.	Damp.	Wet.	Med.	Damp.	Wet.	Med.	Damp.	Wet.	Med.	Damp.
Gravel.....	do.	do.	do.	do.	do.	do.	do.	do.	do.	do.	do.	do.
Limestone.....	do.	do.	do.	do.	do.	do.	do.	do.	do.	do.	do.	do.
Cinders.....	do.	do.	do.	do.	do.	do.	do.	do.	do.	do.	do.	do.

NOTE.—Three beams, three cylinders, and three cubes were made for each variation shown in the table.

METHODS OF TESTING.

The methods of testing beams of 12-foot and variable spans, together with cylinders and cubes, have been described in considerable detail in Bulletin No. 329. It is thought best, however, to repeat and in some cases amplify matter which appears there, as the intelligent interpretation of much of the test data is greatly aided by ready access to an account of the methods of testing that were used.

RESULTS OF TESTS.

No attempt has been made in this bulletin to generalize the results of the tests herein presented, or to draw any conclusions, however warranted they may appear from an examination of the test data. It is hoped that the matter herein contained will provoke discussion, and in order to promote this end extended expressions of opinion or attempted applications of theory to results have been avoided. A running commentary on the results of the tests, however, emphasizing matters of particular interest and indicating a few points that might lead to interesting analyses, is included in this report. When the results of the 52-week tests become available it is the intention to publish a thorough analysis of the entire series in another bulletin.

The purpose of this series of tests was to determine—

- (1) The effect of age on the strength of concrete;
- (2) The effect of variation in the consistency on the strength of concrete; and
- (3) The effect of different types of aggregates on the strength of concrete.

The first question is perhaps the most important, since an early attainment of considerable strength and no subsequent decrease in

strength are two essential qualities in concrete, in order that a structure may be put to the use for which it is intended as soon as possible and that there shall be no subsequent deterioration in strength.

The least age at which any tests were made was four weeks, and at that period in no case except that of the cinder concrete, wet consistency, did the compressive strength fall below 2,000 pounds per square inch, while the cinder concrete had in every case a compressive strength of at least 1,000 pounds per square inch.

In every instance the compressive strength shows a substantial increase from four to thirteen weeks, with the single exception of limestone concrete mixed to a wet consistency, for which a decreased strength is indicated by the tests, a decrease which continues to the age of twenty-six weeks. This decrease in the strength of the limestone concrete is unexplainable, and the results of the 52-week tests on this material will be of value as indicating whether or not this decrease continues to the latter period. The other aggregates show either the same or a slightly greater strength at twenty-six weeks than at thirteen weeks.

The transverse tests on both the long and the short beams bear out very closely the fact indicated by the compression tests on the cylinders and cubes, and lead to the belief that the tensile and compressive strength are affected alike by both age and consistency. The effect on the strength of the variation in the consistency is clearly shown. In almost every case the concrete of the damp consistency is the strongest and that of the wet consistency the weakest. This is true for the three ages at which the concrete was tested, and is confirmed by the tests of the beams as well as of the cylinders and the cubes. Attention is called to the fact that the damp consistency used is much wetter than the damp consistency used in making mortar building blocks, for which the same conclusions may not apply.

The difference in strength of the stone and gravel concretes of the three consistencies is more pronounced than in the case of the cinder concrete. The effect of the consistency on the strength seems to depend to a great extent on the behavior of the concrete while being tamped and to the method used in tamping. Great care was taken to tamp all the concretes in the same manner. The thorough mixing of the concrete is absolutely essential and has a marked influence on the consistency.

The relatively slight influence exerted by the consistency on the strength of cinder concrete may be partly due to the structural weakness of the cinders themselves, which in the drier mixtures were to a great extent broken up by the tamper, while in the wet mixtures, the cinders would move from beneath the tamper.

While it is true that in almost every instance the drier mixtures give the greater strength, it does not follow that dry (or damp)

mixtures should be used in construction. Practical considerations warrant the use of a wet mixture. The difficulty in securing efficient tamping and a smooth finish in a damp concrete, the loss of strength due to the unavoidable drying out of the concrete used above water, the difficulty of securing in reinforced concrete an intimate union with the steel, and the far greater ease of placing wet concrete all seem to warrant the sacrifice of what in many cases is but a slight difference in strength for a greater ease of manipulation and a thorough bedding of the steel, which is of the utmost importance in reinforced concrete work.

It is dangerous to draw any general conclusions as to the relative value of concrete made of the four aggregates used unless the character of the aggregates used in this particular series of tests is carefully kept in mind. The gravel, granite, limestone, and cinders were used as available representative types of aggregates, and while the results indicate that the granite makes the strongest concrete, it should not be assumed, therefore, that a granite concrete is stronger than a gravel, limestone, or cinder concrete. Every material should be accepted or rejected on the results of the tests of its qualities, regardless of the tests of other materials of the same type. Apparently insignificant differences in two materials which appear to be similar often cause considerable difference in the strength of concrete made from them. For instance, two limestones from the same quarry crushed and screened under similar conditions—except that one was screened while wet, which caused the dust to adhere to the surface of the stone—would make concretes of considerable difference in strength.

Because the hard, flinty gravel used in these tests gave excellent results, it does not necessarily follow that a similar well-graded gravel, but composed of soft limestone or shale, would give like results. No series of investigations, however elaborate, will do away with the necessity of careful inspection of the materials to be used. The relative value of materials reported in this bulletin should be recognized, therefore, as applicable only to the particular materials from which the reported physical properties were obtained.

ACKNOWLEDGMENTS.

All the material used in the tests herein reported was donated by the following companies, who deserve credit for their interest and hearty cooperation in advancing the work:

Cement.—Iola Portland Cement Company, Iola, Kans.

Atlas Portland Cement Company, Hannibal, Mo.

Whitehall Portland Cement Company, Cementon, Pa.

Universal Portland Cement Company, Chicago, Ill.

Edison Portland Cement Company, New Village, N. J.

Omega Portland Cement Company, Mosherville, Mich.

Old Dominion Portland Cement Company, Fordwick, Va.

Lehigh Portland Cement Company, Mitchell, Ind.

St. Louis Portland Cement Company, St. Louis, Mo.

Sand.—Union Sand and Material Company, St. Louis, Mo. A recent river sand dredged from Meramec River at Drake, Mo.

Gravel.—Union Sand and Material Company, St. Louis, Mo. A recent river gravel dredged from Meramec River at Drake, Mo.

Granite.—Schneider Granite Company, St. Louis, Mo. A hard, red granite quarried near Graniteville, Mo.

Cinders.—United Railways Company, St. Louis, Mo. These cinders were obtained from the Dehodium power house, St. Louis, and gave better results than those selected from other sources.

Limestone.—Fruin-Bambrick Construction Company, St. Louis, Mo. Obtained from a quarry in St. Louis.

The tests were supervised by Louis H. Losse, and the results were computed and collated by Harry Kaplan.

TESTS OF CONSTITUENT MATERIALS.

CEMENT.

PREPARATION OF TYPICAL CEMENT.

The cement used in all the tests in these laboratories is known as typical Portland cement. It is prepared by thoroughly mixing together a number of Portland cements. The method of preparing the typical Portland cement that was used in the tests herein reported and in the tests on the second and third series, reinforced beams, including in all 576 beams, cylinders, and cubes, was as follows:

One thousand eight hundred sacks of cement, 200 from each of nine companies, were used. Two hundred sacks of one brand were spread over a concrete floor 25 by 40 feet in area and thoroughly mixed by hoeing from side to side. Two samples were then taken, a 50-pound sample for tests to be made by the constituent-materials section, and a smaller one for chemical tests. The cement was then resacked. When all the brands had been separately mixed in this way, two sacks of each brand were spread on the floor in a layer about 3 inches thick. One brand was spread upon another in blanket form, making nine separate layers of cement for the nine brands used. The mass was mixed very carefully with shovels until a uniform mixture was obtained. A 10-pound sample was taken for physical tests and the cement was sealed in air-tight cans, two cans of 800 pounds capacity each being required to hold one mix.

RESULTS OF TESTS.

Table 1 contains the results of the chemical tests of the individual brands, made on samples taken as indicated above. The average of the columns may be taken as the analysis of the typical Portland cement.

TABLE 1.—*Chemical analyses of individual brands used in the preparation of typical Portland cement.*

Cement No.	Silica (SiO ₂).	Alumina (Al ₂ O ₃).	Ferric oxide (Fe ₂ O ₃).	Lime (CaO).	Mag- nesia (MgO).	Sul- phuric anhy- dride (SO ₃).	Water (H ₂ O).	Ignition loss.	Unde- ter- mined.
200.....	20.34	9.36	3.04	63.40	1.35	1.47	.....	.....	1.04
201.....	22.12	6.50	3.22	61.39	2.58	1.89	0.94	0.55	.97
202.....	20.96	8.08	2.80	62.68	1.45	1.54	.18	1.61	.70
203.....	20.52	8.54	2.68	62.47	1.92	1.50	.29	1.43	.65
204.....	20.04	7.70	2.74	63.26	2.24	1.56	.08	.96	1.60
205.....	22.04	9.50	1.42	61.46	1.68	1.58	.55	.84	.93
206.....	22.80	9.56	1.06	61.04	1.37	1.82	.64	.77	.94
207.....	22.96	9.34	1.32	61.20	1.47	1.81	.28	.86	.76
208.....	23.48	8.22	1.80	61.10	1.62	1.68	.44	.81	.85
Average.....	21.70	8.53	2.23	62.00	1.74	1.67	.43	.98	.94

Table 2 contains the results of the physical tests, except those for strength of the individual brands. All these tests were made according to the methods recommended by the special committee on uniform tests of cement of the American Society of Civil Engineers.

TABLE 2.—*Physical tests of individual brands used in typical Portland cement.*^a

Cement No.	Residue on sieve (per cent)—		Specific gravity.	Water (per cent).	Time of set (minutes).				Normal pat tests.	
					Vicat.		Gillmore.		Air (70° F.).	Water (70° F.).
	100.	200.			Ini- tial.	Final.	Ini- tial.	Final.		
200.....	5.9	20.9	3.136	21.0	184	340	155	325	Normal.....	Normal.
201.....	5.5	22.1	3.058	20.5	93	378	110	486	.....do.....	Do.
202.....	7.8	24.6	3.121	20.5	138	329	152	393	.....do.....	Do.
203.....	4.4	20.6	3.099	21.5	117	315	150	352	Crack 1" long 1" from edge.	Do.
204.....	2.0	12.0	3.087	24.0	124	416	229	458	Normal.....	Do.
205.....	6.0	22.2	3.165	21.0	127	370	178	394	Warped 1/4" from edge.	Do.
206.....	5.3	21.5	3.127	21.0	113	338	195	441	Normal.....	Do.
207.....	6.0	23.2	3.129	20.5	146	391	182	372	.....do.....	Do.
208.....	3.1	21.6	3.141	22.5	170	332	217	400	.....do.....	Do.
Average.....	5.1	21.0	3.108	21.4	135	357	174	402		

^a In the accelerated pat tests, in water at 212° F. for 3 hours and in steam maintained at normal pressure for 5 hours, the results were normal in each case for each brand of cement.

Table 3 contains the results of the strength tests of the individual brands. Tests were made for both neat cement and 1:3 mortar with Ottawa sand, in tension, compression on 2-inch cubes, and modulus of rupture on a 1 by 1 inch prism tested by a center load on a 12-inch span. All tests were made according to the methods recommended by the special committee on uniform tests of cement of the American Society of Civil Engineers.

TABLE 3.—Strength tests of individual brands used in the preparation of typical Portland cement.

Cement No.	Temperature (°F.).				Water (per cent).	Strength of neat test pieces (pounds per square inch).														
	Air.	Water.	Closet	Tanks.		Tensile.			Compressive.						Transverse.					
						1 day.	7 days.	28 days.	1 day.	7 days.	28 days.	90 days.	180 days.	1 day.	7 days.	28 days.	90 days.	180 days.		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
200.	64.4	68.0	64.4	53.6	21.0	332	655	864	859	886	2,375	10,090	11,130	12,918	17,820	702	1,962	2,088	2,070	2,070
	64.4	68.0	64.4	53.6	21.0	324	698	870	842	878	2,500	9,225	11,310	13,200	18,172	828	1,800	2,068	2,124	2,124
	64.4	68.0	64.4	53.6	21.0	332	672	852	846	859	2,400	10,925	10,660	13,570	16,542	792	1,980	2,124	2,196	2,232
Average.	68.8	68.0	61.4	70.0	20.5	329	675	862	849	874	2,425	10,080	10,833	13,129	17,511	774	1,914	2,070	2,130	2,142
201.	68.8	68.0	61.4	70.0	20.5	144	616	772	835	880	1,425	5,895	8,100	11,520	11,450	396	1,224	1,674	2,016	1,980
	68.8	68.0	61.4	70.0	20.5	172	601	729	886	861	1,400	5,638	8,655	12,225	11,038	414	1,260	1,548	1,860	1,944
	68.8	68.0	61.4	70.0	20.5	171	601	728	842	848	1,400	5,088	8,022	11,965	11,360	.....	1,278	1,710	2,061	1,908
Average.	64.4	68.0	64.4	68.9	20.5	162	608	743	854	863	1,413	5,540	8,239	11,903	11,279	405	1,254	1,644	2,019	1,944
202.	64.4	68.0	64.4	68.9	20.5	401	754	792	842	832	3,900	9,250	12,272	13,825	702	1,682	1,764	1,962	1,926	1,926
	64.4	68.0	64.4	68.9	20.5	475	725	776	803	881	3,750	8,125	9,775	11,905	14,060	702	1,584	1,728	1,834	1,834
	64.4	68.0	64.4	68.9	20.5	457	746	788	826	861	3,892	8,025	9,300	12,066	14,187	648	1,728	1,786	1,935	1,980
Average.	66.4	68.0	68.9	73.4	21.5	399	562	781	827	840	2,400	6,778	9,425	11,525	13,525	792	1,296	1,728	1,977	1,914
203.	66.4	68.0	68.9	73.4	21.5	312	582	814	886	835	1,625	7,300	8,867	11,312	14,028	774	1,200	1,908	1,980	1,980
	66.4	68.0	68.9	73.4	21.5	292	548	808	881	854	2,125	6,940	8,880	12,022	13,842	972	1,404	1,960	1,960	2,124
Average.	68.0	68.0	66.2	71.6	24.0	301	565	801	865	843	2,050	7,023	9,057	11,620	13,798	846	1,320	1,824	1,953	2,052
204.	68.0	68.0	66.2	71.6	24.0	276	622	715	790	835	2,325	6,675	9,200	11,457	14,025	558	1,368	1,710	1,926	2,088
	68.0	68.0	66.2	71.6	24.0	285	640	712	815	837	2,200	6,035	8,125	11,225	13,022	576	1,368	1,656	1,908	2,052
	68.0	68.0	66.2	71.6	24.0	275	623	732	821	826	2,225	6,196	8,475	13,705	15,581	558	1,296	1,656	1,908	2,016
Average.	72.0	68.0	71.6	74.3	21.0	279	628	720	809	833	2,250	6,308	8,600	11,341	13,597	564	1,344	1,656	1,908	2,052
205.	72.0	68.0	71.6	74.3	21.0	305	638	790	820	855	2,075	6,550	10,125	11,800	13,655	684	1,350	2,032	1,976	2,124
	72.0	68.0	71.6	74.3	21.0	308	616	762	811	862	1,975	7,030	9,675	12,155	13,972	720	1,476	1,820	1,926	1,980
	72.0	68.0	71.6	74.3	21.0	326	620	806	869	868	2,000	7,175	9,475	11,450	14,137	702	1,386	1,962	2,032	1,968
Average.	67.6	68.0	67.6	69.8	21.0	313	625	786	813	868	2,017	6,925	9,758	11,802	13,921	702	1,404	2,045	1,985	2,034
206.	70.0	68.0	71.6	69.8	21.0	452	576	758	809	770	3,500	6,625	9,370	11,465	14,377	882	1,584	1,494	1,710	2,088
	70.0	68.0	71.6	69.8	21.0	434	548	735	827	810	3,225	6,975	9,590	11,760	13,747	882	1,584	1,656	1,836	2,016
	70.0	68.0	71.6	69.8	21.0	438	578	742	851	775	3,400	7,300	9,655	11,505	13,712	936	1,602	1,567	1,809	2,024
Average.	74.5	68.0	71.6	69.8	21.0	441	567	745	829	785	3,375	6,907	9,525	11,573	13,945	900	1,578	1,569	1,785	2,070

203.....	66.4	68.0	68.9	73.4	9.1	265	355	431	452	1,700	3,667	4,000	4,400	612	828	684	972
						272	411	446	445	1,775	3,875	4,225	4,225	540	774	738	918
Average.....						275	362	443	456	1,650	3,450	4,100	4,100	558	684	720	945
204.....	68.0	68.0	66.2	71.6	9.5	271	376	440	451	1,708	3,664	4,117	4,242	570	762	714	945
						363	420	465	475	2,100	3,550	3,900	4,325	540	810	936	1,008
Average.....						322	406	472	450	1,975	3,425	3,800	4,450	540	810	918	981
205.....	72.0	68.0	71.6	74.3	9.0	330	394	466	460	2,150	3,725	3,500	4,225	540	810	918	981
						338	407	478	462	2,075	3,567	3,733	4,333	540	810	927	980
Average.....						401	446	465	465	1,625	2,975	3,925	4,375	450	828	1,026	1,008
206.....	70.0	68.0	71.6	69.8	9.0	219	424	430	465	1,775	2,750	3,850	4,500	504	918	972	972
						220	387	449	460	1,625	3,000	3,800	4,625	576	940	954	954
Average.....						229	404	442	469	1,675	2,908	3,868	4,500	510	895	964	990
207.....	73.0	64.4	69.8	66.2	8.9	284	406	460	465	2,100	3,625	4,450	4,500	738	873	972	756
						281	445	436	463	2,100	3,325	3,175	4,400	648	918	900	783
Average.....						272	426	460	475	2,075	3,425	3,125	4,625	720	837	914	774
208.....	66.2	68.0	69.8	65.3	9.3	279	426	460	475	2,092	3,458	3,208	4,462	702	876	929	771
						324	455	498	445	1,900	3,425	4,425	4,975	720	972	990	702
Average.....						330	418	476	438	2,100	3,550	4,400	4,900	666	999	936	720
209.....	66.2	68.0	69.8	65.3	9.3	358	464	452	450	2,250	3,650	4,275	4,950	666	1,026	936	720
						337	446	472	444	2,063	3,542	4,367	4,942	684	999	954	714
Average.....						327	427	535	496	2,225	3,750	4,162	4,225	720	1,539	1,008	684
Grand average.....						330	472	509	521	2,350	3,500	4,760	4,575	738	1,566	985	702
						462	530	526	526	2,200	3,650	4,400	4,400	666	1,566	1,026	756
						316	454	525	514	2,258	3,633	4,460	4,400	708	1,557	1,006	714
					9.1	294	409	457	468	2,105	3,572	3,905	4,343	563	920	907	847

TABLE 4.—Physical properties of cements used in concrete beams.

Register No.	Specific gravity.	Temperature (°F.).		Water (per cent).	Time of set (minutes).				Residue on sieve (per cent).—		Tensile strength of neat cement (pounds per square inch).					Soundness (as indicated by appearance of pat).
		Water.	Air.		Vicat.		Glimmore.		100.	200.	1 day.	7 days.	28 days.	90 days.	180 days.	
					Initial.	Final.	Initial.	Final.								
209.....	3.112	75.2	71.6	21.0	138	370	180	403	4.8	19.8	422	696	841	704	836	Pat A, warped $\frac{1}{4}$ inch around edge.
210.....	3.116	75.2	71.6	21.0	137	372	239	429	4.6	20.8	468	698	816	714	836	Normal.
211.....	3.111	75.2	71.6	21.0	132	386	226	430	5.0	22.4	496	678	828	757	843	Pat D, warped $\frac{1}{4}$ inch around edge.
213.....	3.111	74.0	70.6	21.0	180	389	275	430	5.2	20.8	451	687	799	792	857	Pat C, warped $\frac{1}{4}$ inch around edge.
214.....	3.116	74.0	70.6	21.0	195	379	262	410	5.0	21.8	470	758	848	769	851	Normal.
218.....	3.108	75.0	71.6	21.0	200	443	192	475	4.9	21.3	373	770	769	812	829	Do.
219.....	3.113	75.0	71.6	21.0	195	432	275	470	4.8	20.7	371	793	785	798	822	Do.
220.....	3.112	77.0	65.0	21.0	222	446	279	512	5.0	20.8	382	757	765	795	833	Do.
223.....	3.113	73.0	68.0	21.0	174	435	245	472	4.7	21.2	425	723	791	801	821	Do.
224.....	3.114	73.0	68.0	21.0	192	415	250	474	4.7	21.1	451	735	782	790	836	Do.
225.....	3.118	73.0	68.0	21.0	182	419	242	466	5.4	21.0	451	749	791	816	863	Do.
226.....	3.113	73.0	68.0	21.0	171	411	231	457	5.1	20.8	424	749	791	816	849	Do.
227.....	3.113	70.0	68.5	21.0	203	438	271	478	4.8	20.7	372	722	821	831	883	Do.
229.....	3.113	67.1	72.5	21.0	180	443	223	485	5.0	21.4	409	809	827	831	794	Do.
230.....	3.115	67.1	72.5	21.0	195	443	243	472	4.9	21.4	389	731	871	835	839	Do.
231.....	3.110	67.1	72.5	21.0	206	443	243	472	4.9	21.4	427	769	881	871	841	Do.
232.....	3.109	68.0	55.4	21.0	194	458	235	460	5.0	21.6	441	768	890	829	838	Do.
233.....	3.114	68.0	55.4	21.0	200	408	265	505	5.2	21.5	290	645	857	846	870	Do.
335.....	3.114	68.0	55.4	21.0	233	470	282	484	4.6	20.7	316	645	858	839	842	Do.
336.....	3.113	64.4	48.2	21.0	262	472	298	487	4.5	20.5	220	675	886	857	911	Do.
237.....	3.115	64.4	48.2	21.0	263	454	250	357	4.5	20.5	221	648	877	846	887	Do.
271.....	3.115	68.0	50.0	21.0	300	500	357	532	4.7	21.1	309	742	826	823	876	Do.
272.....	3.118	68.0	50.0	21.0	238	381	255	465	4.8	21.4	433	729	841	855	864	Pat A, 2-inch shrinkage crack $\frac{1}{4}$ inch from edge.
274.....	3.111	68.0	59.0	21.0	219	432	353	451	4.8	21.2	420	739	829	839	877	Pat A, 1-inch shrinkage crack $\frac{1}{4}$ inch from edge.
275.....	3.116	68.0	68.0	21.0	170	416	143	403	4.8	21.4	387	786	791	790	859	Pat A, 1½-inch shrinkage crack $\frac{1}{4}$ inch from edge.
283.....	3.111	68.0	70.0	21.0	147	419	175	404	4.9	21.1	404	717	805	840	851	Normal.
289.....	3.114	68.0	70.0	21.0	138	240	239	444	5.0	21.1	421	725	760	830	874	Do.
291.....	3.113	68.0	75.0	21.0	153	377	184	405	4.9	21.0	431	761	774	816	856	Do.
292.....	3.114	68.0	75.2	21.0	139	369	189	405	4.9	21.1	436	777	758	814	860	Normal.
293.....	3.112	68.0	75.2	21.0	152	394	259	456	4.7	20.7	425	768	765	819	871	Do.
301.....	3.112	68.0	74.5	21.0	134	450	297	486	4.9	21.5	427	799	798	829	867	Do.
302.....	3.110	68.0	74.5	21.0	190	466	318	517	4.8	21.3	433	760	803	821	868	Do.
303.....	3.110	68.0	59.9	21.0	208	447	290	508	5.0	21.6	428	759	796	835	870	Do.
304.....	3.113	68.0	59.9	21.0	225	464	320	524	4.7	21.4	422	732	783	828	870	Do.
309.....	3.111	68.0	70.7	21.0	156	388	227	461	4.8	21.5	403	733	727	818	868	Do.
312.....	3.110	68.0	62.6	21.0	176	425	215	468	4.8	21.6	386	729	823	838	843	Do.

[illegible]

Table 4 contains the results of all the physical tests made of the typical Portland cement that was used in the present series of concrete beams. In the column "Register No." is given the register number of the cement used. Each number corresponds to two cans of 800 pounds each of typical Portland cement. The sample for each test was taken as already indicated.

As these tests were made with the sole idea of checking the uniformity with which the typical Portland cement was prepared, a full series of neat and sand tests was thought unnecessary and undesirable, for it would entail too much routine work on the part of the constituent-materials laboratory. Accordingly, only tension tests on neat cement were made.

SAND.

The same sand was used with all the aggregates tested. It is known as Meramec River sand, and is composed of flint grains having comparatively smooth surfaces. The yellowish-brown color of the flint imparts a tint of the same color to the sand as a whole.

Tables 5 and 6 (p. 17) give the results of the physical tests on this material. The granulometric analysis in Table 6 shows the sand to be rather finer than desirable. The percentage of voids was computed from the weight per cubic foot and the specific gravity.

Table 7 (p. 18), which contains the results of the tests made on the cement used in the preparation of the test pieces reported in Table 5, will aid in the interpretation of the values given in the latter table.

TABLE 5.—Tests of mortar made with Meramec River sand (Sd. 43) and typical Portland cement (Ct. 140) in concrete beams.

Fineness of sand.	Proportion of mortar.	Temperature (°F.).		Tensile strength (pounds per square inch).				Compressive strength (pounds per square inch).				Transverse strength (pounds per square inch).			
		Air.	Water.	7	28	90	180	7	28	90	180	7	28	90	180
				days.	days.	days.	days.	days.	days.	days.	days.	days.	days.	days.	days.
Passed 1-inch screen.	1:3.....	71.0	68.0	274	438	418	443	2,375	4,075	5,625	5,125	594	882	1,044	972
	1:4.....			263	422	415	467	2,250	4,175	5,425	4,900	576	936	1,008	1,008
	Average.....			260	416	446	487	2,325	4,050	5,650	5,210	594	846	1,026	972
	1:3.....	71.0	68.0	266	425	426	466	2,317	4,100	5,567	4,968	588	888	1,026	1,080
Size, 30-40.....	1:4.....			180	302	352	391	1,375	2,450	3,625	3,600	396	612	810	846
	Average.....			186	294	332	355	1,375	2,350	3,900	3,675	396	606	864	900
	1:3.....	65.0	68.0	190	306	361	373	1,325	2,375	3,812	3,550	378	630	882	900
	Average.....			185	301	355	373	1,358	2,392	3,780	3,608	390	636	852	870
Size, 30-40.....	1:3.....			215	293	343	359	1,425	2,750	3,400	3,550	396	630	882	828
	Average.....			224	294	350	372	1,400	2,700	3,450	3,500	414	648	954	900
	1:3.....			207	290	344	335	1,425	2,650	3,375	3,675	432	612	864	882
	Average.....			215	295	346	349	1,417	2,700	3,408	3,575	414	630	900	822

TABLE 6.—Physical properties of sand and other materials forming aggregates used in concrete beams.

Kind of material.	Specific gravity.	Percent- age of voids (com- puted).	Weight (pounds per cubic foot).	Percentage passing sieve or screen—								1½-inch.	1-inch.	¾-inch.	½-inch.	¼-inch.
				200.	100.	80.	50.	40.	30.	20.	10.					
Cinders.....	1.530	50.7	47.0	2.84	4.17	4.91	6.45	8.26	10.48	13.66	21.07	36.89	60.32	81.44	89.68	100
Granite.....	2.585	40.9	95.3	1.59	2.29	2.62	3.22	3.74	4.38	5.45	8.50	19.88	57.54	92.25	99.71	100
Gravel.....	2.450	33.0	102.4	0	0	0	0	0	0	0	0	95	43.0	95.2	98.5	100
Limestone.....	2.489	37.1	97.7	2.96	3.48	3.70	4.18	4.68	5.23	6.21	10.69	28.71	60.86	96.04	99.37	100
Meramec River sand.....	2.597	37.9	100.6	.20	1.30	3.60	13.90	37.00	64.00	81.50	97.00	100				

AGGREGATE.

The results of the physical tests on the granite, gravel, cinders, and limestone used in the plain beams are reported in Table 6. The crushing strength of the 1:2:4 concrete made of these aggregates is given in connection with the results of tests on the plain beams, in Table 10 (pp. 48-53).

TABLE 7.—Tests of cement 140, used in testing Meramec River sand (strength in pounds per square inch).

Kind of test.	Neat.						1:3 mortar.				
	1 day.	7 days.	28 days.	90 days.	180 days.	360 days.	7 days.	28 days.	90 days.	180 days.	360 days.
Tension.....	362	710	696	775	827	846	342	527	445	405	414
	375	700	705	792	811	853	375	540	445	388	408
	372	718	709	781	813	831	364	531	413	394	405
Average.....	370	709	703	783	817	843	360	533	434	396	408
Compression.....	3,425	9,300	10,512	12,288	13,980	14,274	1,570	3,200	.....	5,025	5,500
	3,275	9,325	11,125	12,612	13,725	14,410	1,555	3,300	3,698	5,025	5,425
	3,300	9,175	10,497	12,862	13,803	14,320	1,735	3,025	3,400	4,800	5,239
Average.....	3,333	9,266	10,711	12,590	13,836	13,335	1,620	3,175	3,549	4,950	5,388
Transverse.....	756	1,440	1,872	1,998	1,944	2,142	.....	.....	.....	.....	.....
	792	1,440	1,908	2,016	2,088	2,232	.....	.....	.....	.....	.....
	774	1,476	1,944	1,962	2,034	2,124	.....	.....	.....	.....	.....
Average.....	774	1,452	1,908	1,992	2,022	2,166	.....	.....	.....	.....	.....

Remarks.—Fineness: Residue on No. 100 sieve, 6.8 per cent; on No. 200 sieve, 22.8 per cent. Specific gravity, 3.12. Time of set: Initial, 142 minutes; final, 428 minutes. Soundness: Pat test in air at 70° F., normal; in water at 70° F., normal; in water at 212° F., 3 hours, normal; in steam at normal pressure, 5 hours, normal. Water used in mixing: Neat, 20.5 per cent; mortar, 8.9 per cent. Temperatures: Of air, 71.0° F.; of water, 68.0° F.

PREPARATION OF TEST PIECES.

METHODS OF PROPORTIONING.

A 1:2:4 volume proportion was adopted for all the concrete used in the following tests. Since, however, the volume of a given weight of dry sand is greatly affected by the percentage of moisture present, it was thought best to do the actual proportioning by weight. The weight of 1 cubic foot of cement was assumed to be 100 pounds. The weight per cubic foot of the dry, loose sand and the dry, loose aggregate as determined by tests in the constituent-materials laboratory, was used in reducing the proportions by volume to the proportions by weight.

With this as a basis, the necessary weight of dry material for the desired batch was determined. Since the sand and stone, as stored in the bins, contained an appreciable amount of moisture, the dry weight of the material had to be increased by the weight of the moisture present before the batch could be weighed out. The percentage of moisture was determined on a 500-gram sample of the sand and stone each day on which beams were molded.

The above method of correcting for moisture was followed in the series of concrete beams and in the greater part of the first reinforced beam series. It was noticed from time to time, however, that the concrete when dumped from the mixer was not always of the same consistency, in spite of the fact that the total weight of water present (weight of water added plus the weight of the moisture in the sand and the stone) was a constant. A moisture determination was then made on a sample representing as nearly an average of the material in the bin as it was possible to obtain, and this was then maintained constant and gave much better results. The effect on the consistency of a given change in the weight of the moisture in the sand or stone does not appear to be the same as that of an identical change in the weight of the water added to the batch, the difference probably being due to the fact that the moisture test is only local and does not represent the true average of the material in the bin.

It should be noted here that the proportions by volume of the cinder concrete are nearer 1:2:5 than 1:2:4. This is due to an error in making the moisture determination at the time the weight per cubic foot was determined. The weight per cubic foot of the cinders, including apparently 11.1 percent moisture, was reported as 68.1 pounds. Using these figures gives 61.3 pounds per cubic foot for the weight of the dry, loose cinders. These determinations were accepted as correct until a sample, which had been forgotten in the oven, showed 23 per cent moisture present. This error in the weight per cubic foot, due to insufficient drying of the test sample, was not discovered until the series of cinder beams was almost completed. While a new determination of the weight per cubic foot was made and the proportions by weight and volume modified accordingly, it was thought best to use these proportions and the correct weight per cubic foot on the remaining cinder beams rather than the 1:2:4 volume proportions, in order to make the cinder beams comparable among themselves even if not strictly comparable with the beams of other aggregates.

The weight per cubic foot, as redetermined, was found to be 47.0 pounds.

METHOD OF MIXING AND CONSISTENCY.

MIXING.

All concrete was mixed in a motor-driven cubic-yard cube mixer, which is equipped with a charging hopper. All water used in mixing concrete was weighed and was supplied to the mixer through a hose attached to a water barrel, which is mounted on a platform scale on a support above the mixer. To insure uniform conditions the interior of the mixer was wetted down each morning before the first mix of the day. All concrete was mixed two minutes dry and three minutes

wet, after which it was dumped on the cement floor, shoveled into wheelbarrows and wheeled to the molding floor. Sufficient material was charged into the mixer to make two beams, two cylinders, and two cubes from the same batch of concrete.

CONSISTENCY.

Definition.—The three consistencies, wet, medium, and damp, as here used, represent each a certain characteristic behavior and appearance of the concrete in the mixer, on the floor, and in the mold when subjected to tamping. In order to eliminate the personal equation as far as possible, the amount of water required to bring the batch to a desired consistency for a particular aggregate was carefully determined by trial before the test pieces were molded. Thereafter the weight of water to be used with each aggregate for that consistency could be obtained by making a simple correction each day, depending upon the percentage of water contained in the aggregate as it came from the bins. The total amount of water, including moisture, was expressed as a percentage of the total weight of the dry material and was maintained constant.

A brief description of the consistencies is given. It should be recognized that the consistencies as defined are purely arbitrary, but each, it is thought, represents a characteristic appearance and behavior, and, with a little practice, is readily distinguished from the others.

Wet consistency.—Concrete of wet consistency has a smooth and somewhat viscous appearance in the mixer, or immediately before dumping. It flows back from the ascending side of the mixer without any tendency toward “breaking” over at the top. The upper surface of the concrete in the bottom of the mixer rolls underneath the mass smoothly and is carried upward by adhesion to the metal. When dumped, it stands on the floor in a low pile, having a smooth surface, and showing neither voids nor individual stones. It can not be compacted by tamping in the molds, but splashes under the action of the tamper. When finished, water stands from one-fourth to one-half inch deep over the surface of the mold.

Medium consistency.—Concrete of medium consistency has a smooth appearance in the mixer, but shows a tendency to lump. As compared to that of wet consistency it flows less smoothly and is carried higher by the ascending side of the mixer, part flowing back smoothly and part breaking over at the top in lumps. When dumped, it stands in a higher pile with steeper side slopes, exhibiting a somewhat lumpy appearance, and showing individual stones, but no voids. The stones show an even coating of sand mortar. No water collects on the surface of the beam in the mold. The surface is easily finished with a trowel.

Damp consistency.—Concrete of damp consistency is decidedly granular in the mixer with little tendency to lump. The material is carried to the top of the mixer and falls in individual stones and fragments of mortar. When dumped, it stands at the same angle as medium concrete, showing both individual stones and voids. The surface of the pile is irregular. In the mold it offers considerable resistance to tamping, but compacts fairly well under hand tamping. No water flushes to the surface and it can not be finished smooth by troweling.

METHOD OF MOLDING.

BEAMS.

The beam molds consisted of three long steel channels with flanges turned outward, forming the sides and bottom of the mold. The ends were closed by short pieces of channels. The side and end pieces were removable. The molds were oiled before the concrete was placed, to prevent adhesion to the surface of the steel. In molding the plain beams the concrete was deposited in three layers of about equal thickness. The tamping was done by hand with a 13½-pound tamper having a rectangular head 1½ by 3½ inches. The tamping was started at one side of one end of the mold and the tamper moved toward the opposite side, the width of the tamper at each stroke. The tamper was then set forward and the process repeated. In this way each part of the layer was tamped once. The mold was gone over twice in this way, after which the concrete was spaded back from the sides of the mold and the layer tamped a third time. The same operation was followed for each of the three layers. The surface of each beam was finished as smooth as possible by troweling.

The side and end pieces of the mold were removed at the end of twenty-four hours, and the beam was covered with burlap and allowed to remain on the bottom channel until moved into the moist room.

CYLINDERS AND CUBES.

In order to make the compression test representative of the true crushing strength of the concrete in the beam, the cylinders and cubes were molded from the same batch as the beam of the same number. They were molded in cast-iron separable molds, which were oiled previous to placing the concrete. The concrete was deposited in layers approximately 3 inches thick, and each layer was tamped twice, a circular hand tamper 3½ inches in diameter and weighing 7 pounds being used for the cylinders and a rectangular tamper 3½ by 1½ inches, weighing 13½ pounds, for the cubes.

In molding the cubes an effort was made to "spade" back the concrete from the sides of the mold, as was done in molding the beams.

The top surfaces of the cubes and cylinders were finished smooth with a trowel. All molds were removed at the end of twenty-four hours, and the test pieces were marked and transferred to the moist room.

MOVING AND STORAGE.

The large number of beams to be molded and the small space available made it imperative that the beams be moved as soon as possible. In no case could they remain where molded for more than 12 or 16 days. Since a concrete beam without reinforcement, and weighing about 1,200 pounds, has very little tensile resistance at this age, it was very important that they be handled at points that would prevent any chance of injury when being moved to the moist room. The following plan was followed, and was entirely satisfactory:

The channel forming the bottom of the mold was placed with the flanges turned down. At the points where the beams were supported in moving them, the webs of the bottom channels were cut away for a width of $1\frac{3}{8}$ inches. Prior to molding this slot was closed by a filler resting on the uncut flanges. When the beam was to be moved, this filler was driven out and a slightly narrower piece, which projected $1\frac{1}{2}$ inches beyond each side of the beam, was substituted.

A stirrup hanging from the chain blocks suspended from trolleys running on overhead I beams, was hooked under these projecting ends and lifted a 13-foot beam at two points 8 feet apart, which give equal positive and negative bending moment, and consequently minimum stresses in a beam of that length.

The beams in the moist room were stored six high, being supported at the same points as when brought to the damp closet.

All test pieces were sprinkled from a hose three times each day—at midnight, at 8 a. m., and at 4 p. m.—both before and after being placed in the moist room.

The temperature on the molding floor and in the moist room was recorded on a self-recording thermometer, and was maintained as near 70° as possible.

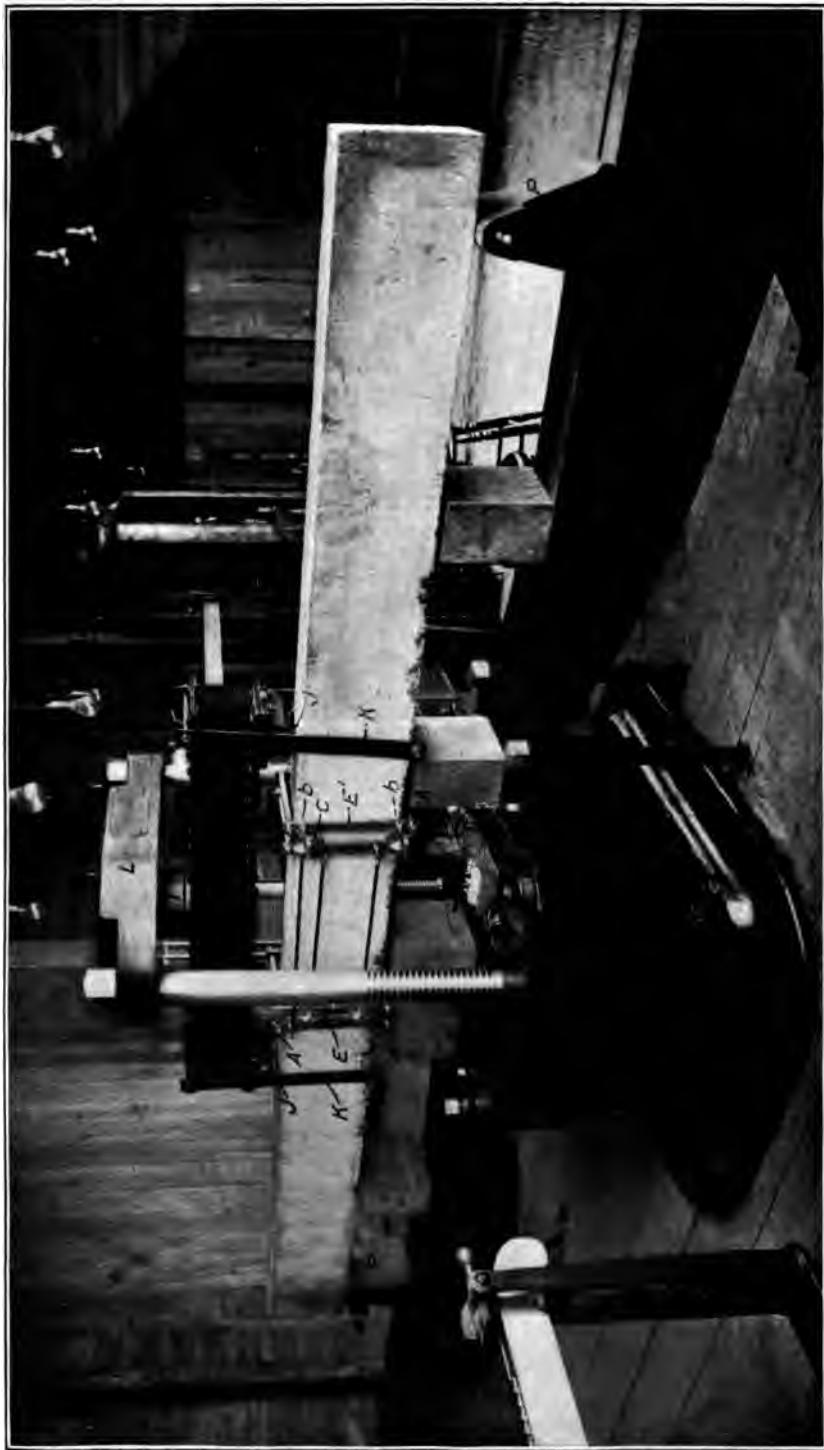
METHODS OF TESTING.

BEAMS.

LONG BEAMS.

APPARATUS.

Pl. I shows a photograph of a beam in place. The supports "P" for the beams have cylindrical top surfaces, and are so designed as to give a slight yielding motion outward, the object being to prevent any restraint of the beam which might follow from the lengthening of the lower fiber.



CONCRETE BEAM IN MACHINE READY FOR TESTING.

Microscopic

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The deformer yokes (E, E') are fastened to the beam by tightening the nuts A, which force the contact points (b) and those directly opposite on the far side of the beam, against the surface of the concrete. The yokes are equidistant from the center of the beam, the contact points being 29.25 inches apart for the outer yokes and 24 inches apart for the inner set. The contact points of the outer set were 10 inches apart vertically and those of the inner yokes 5.75 inches apart. Both yokes were centered on the horizontal axis of the beam, thus bringing the contact points of the outer yokes 0.5 inch below the top and 0.5 inch above the bottom. The inner yokes were used only on some of the earlier beams in order to test the conservation of plane section. Four pins directly in line with the contact points on E engage cylindrical holes in the ends of the four rods, the other ends of which rest lightly on hard rubber rollers fastened to the arms C, which are rigidly connected to the yoke E.

Four micrometer screws reading directly to 0.0001 inch work in bushings fastened to the yoke E'. When any micrometer screw is brought in contact with the end of the corresponding rod, an electric contact is made, which causes a click in the telephone receiver F. Both yokes are divided into two vertical halves by rubber insulation, thus making it possible to read micrometers on both sides of the beam simultaneously.

METHOD OF ZERO DEFORMATIONS.

The deformation of concrete in compression in a beam is obtained from a reading of the upper micrometers, while the lower ones give the elongation of concrete. The readings of both upper and lower micrometers, making the usual assumption of conservation of plane section, fix the position of the neutral axis. The beams were all tested on a 12-foot span by two equal loads, applied at the third points of the span.

The load apparatus consists of a box girder (H) built of two 6-inch channels with a $\frac{1}{2}$ -inch cover plate on the top and the bottom. The load is transmitted from the testing machine to the box girder through a spherical bearing block (I), and from the box girder to the beam by two 2-inch steel rollers (J) bearing on two steel blocks (not shown) set in plaster of Paris. The upper surface of these blocks is a cylinder of very large radius whose axis is parallel to the length of the beam. With the exception of these bearing blocks the entire load apparatus is suspended from the top head (L) of the testing machine by a bolt passing through the spherical bearing block and engaging a plate on the inner surface of the box girder. The steel rollers (J) are kept in place by the casting which extends a trifle below their axis.

On commencing a test the bearing blocks are removed and yokes (K) are passed under the test beam and over the box girder directly above the 2-inch rollers. The head (L) is then run up until the reaction at the ends of the test beam has been so reduced that the total positive bending moment area is equal to the total negative bending moment area within the gage length, considering the beam as a continuous girder over four supports, viz, the two end supports and the two intermediate yokes.

This method is used for the following reason: In tests of beams as usually made, the upper and lower fibers of the beam are already deformed and are under stress due to the weight of the beam when the first, or zero, reading of the deformeters is taken; the deformations computed from these readings are too small by an amount which becomes relatively more and more important as the breaking loads decrease and which in the case of plain beams (many of which fail by a load but little in excess of the weight of the beam) becomes a very large part of the ultimate deformation.

When a beam rests freely on supports, the upper and lower fibers are deformed on account of the bending moment due to the weight of the beam. When the supports are at the ends of the beam the upper fibers are shortened and the lower are lengthened. For equal moduli of elasticity in tension and compression, which are constant for concrete under small loads, the deformation at any point of the beam is proportional to the area of the bending-moment diagram over that length. Therefore, when the total positive bending moment area in the gage length of the deformeters equals the total negative bending moment area in the gage length, the net total deformation in that length is zero, and both the upper and lower fibers of the beam have the same length as when unstressed. For a particular reaction at the ends of the beam the positive bending moment area in the gage length is equal to the negative bending moment area. In order to get this reaction the beams are supported at the third points by the head of the machine as previously described. As the stirrups under the third points of the span take more and more of the weight of the beam the end reactions become smaller and smaller and the character of the bending-moment diagram within the gage length changes until the desired condition is reached.

The method of finding the required reactions for total zero deformations within the gage length, in terms of the weight of the beam and other known quantities, may be understood by reference to fig. 1, as follows:

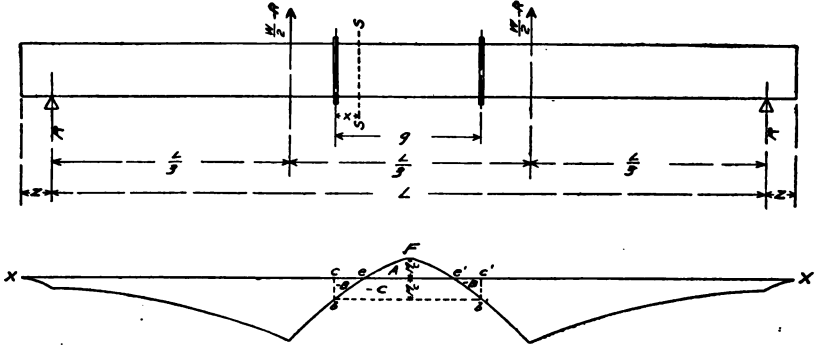


FIG. 1.—Diagrams illustrating method for computation of concrete beams. Upper diagram: Notation used. Lower diagram: Curve of bending moment within gage length (beam supported at third points).

Let L = distance between the supports.

g = gage length of deformeters.

Z = overhang of beam at each end.

$\frac{L}{3}$ = distance from each support to force exerted by each stirrup.

W = total weight of beam.

$\frac{W}{2} - R$ = force exerted by each stirrup at a distance of $\frac{L}{3}$ from the supports.

R = each reaction at end.

SS = any vertical section within the gage length at a distance, x , from one of the gage points.

M_x = bending moment at section SS .

M_o = bending moment at deformeters, where $x = 0$.

M_c = bending moment at center of beam, where $x = \frac{g}{2}$.

m = constant bending moment over the gage length due to the weight of all attachments, such as bearing blocks under the load points and the deformeters. This weight is applied outside of the gage length and equally on each side of the center of the beam.

The bending moment at section SS , considering forces to the left only, is as follows:

$$M_x = R\left(\frac{L}{2} - \frac{g}{2} + x\right) + \left(\frac{W}{2} - R\right)\left(\frac{L}{6} - \frac{g}{2} + x\right) - \frac{W}{2(L+2Z)}\left(\frac{L}{2} + Z - \frac{g}{2} + x\right)^2 + m.$$

Reducing to a simpler form gives:

$$M_x = \frac{RL}{3} - \frac{W}{4} \left(\frac{L}{6} + Z \right) - \frac{W}{4 \left(\frac{L}{2} + Z \right)} \left(\frac{g}{2} - x \right)^2 + m.$$

The bending moment at the end of the gage length ($x=0$) is as follows:

$$M_o = \frac{RL}{3} - \frac{W}{4} \left(\frac{L}{6} + Z \right) - \frac{Wg^2}{16 \left(\frac{L}{2} + Z \right)} + m.$$

The bending moment at the center of the gage length ($x = \frac{g}{2}$) is as follows:

$$M_c = \frac{RL}{3} - \frac{W}{4} \left(\frac{L}{6} + Z \right) + m.$$

The moment diagram between the third points, when there is both positive and negative bending moment in the gage length, is shown in fig. 1, in which xx' is the horizontal axis of the moment diagram. The curve $bee'b'$ is a parabola and crosses the axis at two points (viz, e and e') between the ends of the deformeters. Then in the gage length cc' there is negative bending moment from c to e and from e' to c' , and positive bending moment from e to e' . The dotted lines cb , $c'b'$, and bb' are drawn for the purpose of demonstration. Then the distance M_c represents the bending moment at the center of the gage length, and M_o represents the bending moment at the end of the gage length. The negative bending-moment areas within the gage length are cbe and $c'b'e'$, each being represented by $-B$. The positive bending moment area within the gage length is eFe' and is represented by A .

The condition that the positive bending moment area is equal to the negative bending moment areas is represented by the equation $A = -2B$. Adding the quantity $-C$ to both sides of the equation gives $A + (-C) = -2B - C$. The first part of this equation is the area included between the horizontal line bb' and the parabola bFb' ; that is, $A + (-C) = \frac{2}{3}g [M_c + (-M_o)]$.

The second part of the equation is equal to the area of the rectangle $bcc'b'$; that is, $-2B - C = -gM_o$.

Therefore $\frac{2}{3}g [M_c + (-M_o)] = -gM_o$. Whence $2M_c = -M_o$.

Substituting the values of M_o and M_e as found above gives:

$$\frac{2RL}{3} - \frac{W}{2} \left(\frac{L}{6} + Z \right) + 2m = -\frac{RL}{3} + \frac{W}{4} \left(\frac{L}{6} + Z \right) + \frac{Wg^2}{16 \left(\frac{L}{2} + Z \right)} - m.$$

$$\text{Whence } RL = \frac{3W}{4} \left(\frac{L}{6} + Z \right) + \frac{Wg^2}{16 \left(\frac{L}{2} + Z \right)} - 3m$$

$$\text{and } R = \frac{3W}{4L} \left(\frac{L}{6} + Z \right) + \frac{Wg^2}{16L \left(\frac{L}{2} + Z \right)} - \frac{3m}{L}.$$

In almost all the beams tested at the laboratories L , Z , g , and m are constant. It only remains to find W and to compute R . A table computed by the above formula has been compiled for all the usual values of W , from which the corresponding value of R in any case can be directly read.

METHOD OF TESTING.

When the test is commenced, the top head is run up until the reactions causing equal positive and negative bending moments over the gage length are developed at the ends of the beam. The sum of these reactions will appear on the weighing beam, the testing machine having been balanced before the weight of the beam and all test apparatus comes on it. A full set of deformer readings is then taken.

After the readings at zero total deformations in the gage length and when the beam rests under its own weight are taken, the load is applied in increments of 200 to 1,000 pounds, depending on the stiffness of the beam, the top and bottom set of micrometer readings being recorded on the log sheets. Wood blocks are placed underneath the beam during the test, so that the distance it falls at rupture is not more than one-fourth inch.

SHORT BEAMS.

The longer portion of each beam after first failure is again tested on as great a span as its length permits, thus making a secondary series of short beams.

The load is applied by the same apparatus as that used for the long beams, but instead of being applied at the third points it is applied at points 2 feet from the center of the span. The short beams are not suspended for zero deformation readings, since for such small spans the deformation of the beam under its own weight is very small. On all short beams the outer yokes having a gage length of 29.25 inches are alone used.

CYLINDERS AND CUBES.

The cylinders and cubes are tested on a four-screw, 200,000-pound Olsen machine. To insure an even distribution of load over the entire cross section the ends of the cylinders are bedded in plaster of Paris to a thickness of about one-half inch on a piece of plate glass (previously oiled to prevent adhesion of the plaster). The bearing surfaces are made normal to the axis of the cylinder by means of a spirit level applied to its sides. The cubes are not capped with plaster of Paris, but a thin piece of asbestos is placed on a spherical bearing plate when under test, in order to take up all nonparallelism of the ends.

The load is in each case carried to failure, being applied continuously to rupture in the case of the cubes and in increments of 5,000 pounds, or approximately 100 pounds per square inch for the cylinders. For each increment gross deformations are read on two opposite sides of the cylinder over a gage length of 12 inches.

RESULTS OF TESTS.

BEAMS OF CONSTANT SPAN.

The detailed results of the tests of concrete beams 8 by 11 inches in section, 13 feet long, tested on a 12-foot span by two equal loads applied at the third points are given in Table 8 (p. 36), comprising the

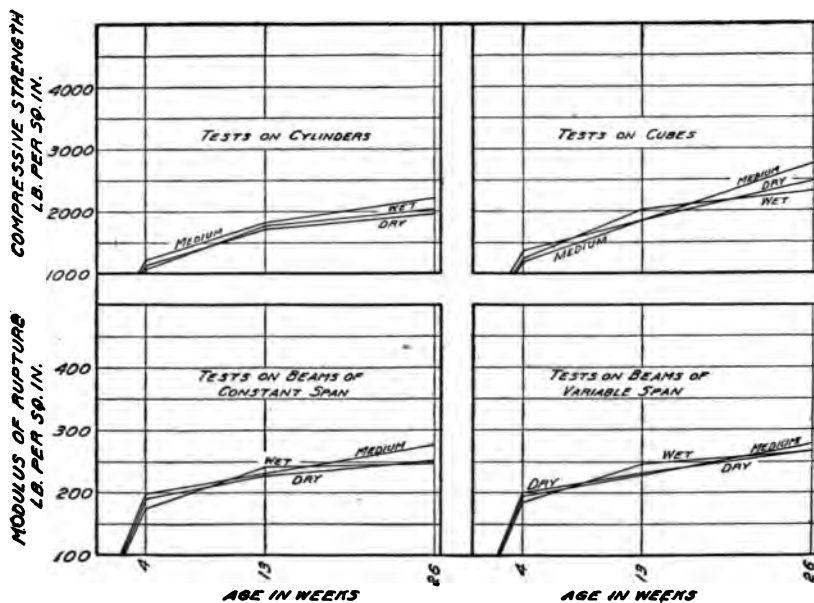


FIG. 2.—Diagrams showing the effect of age and consistency on the strength of cinder concrete.

three ages of 4, 13, and 26 weeks, and some of the results are graphically shown in figs. 2-5 and 10-13.

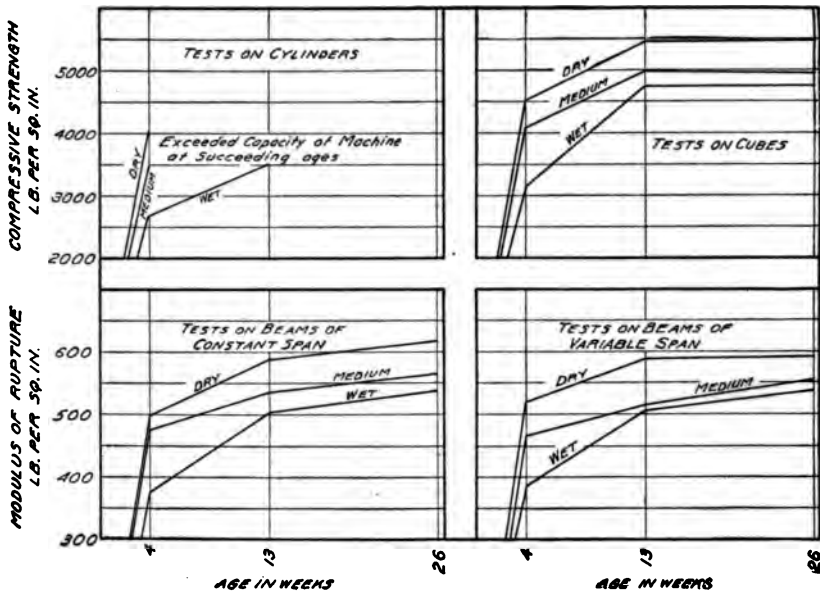


FIG. 3.—Diagrams showing the effect of age and consistency on the strength of granite concrete.

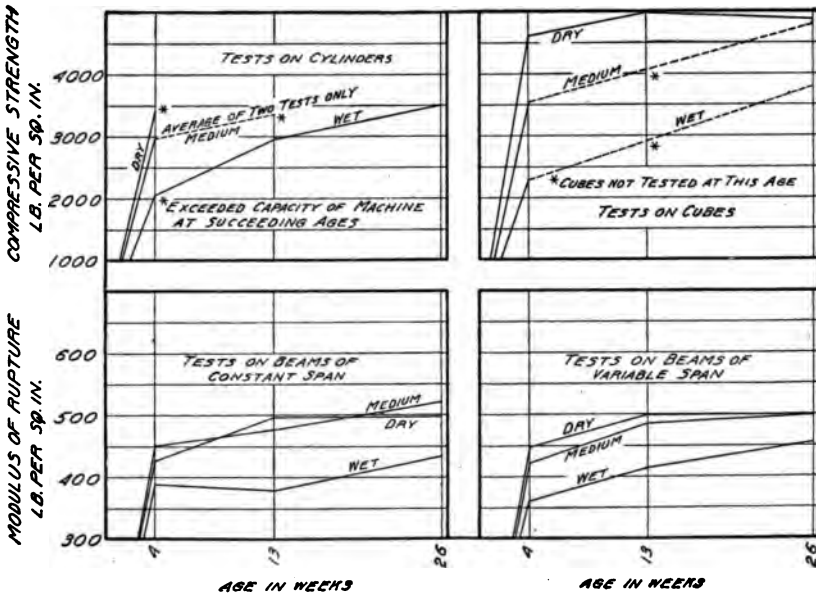


FIG. 4.—Diagrams showing the effect of age and consistency on the strength of gravel concrete.

The percentage of water is expressed in the table in terms of the total weight of the dry material. This percentage includes the weight of the moisture in the sand and aggregate, which varies from

1.5 to 2.0 per cent of the weight of the stone, from 3 to 4 per cent of the weight of the sand, and may include as much as 21 per cent of the weight of the cinders. A simple computation, using the proportions

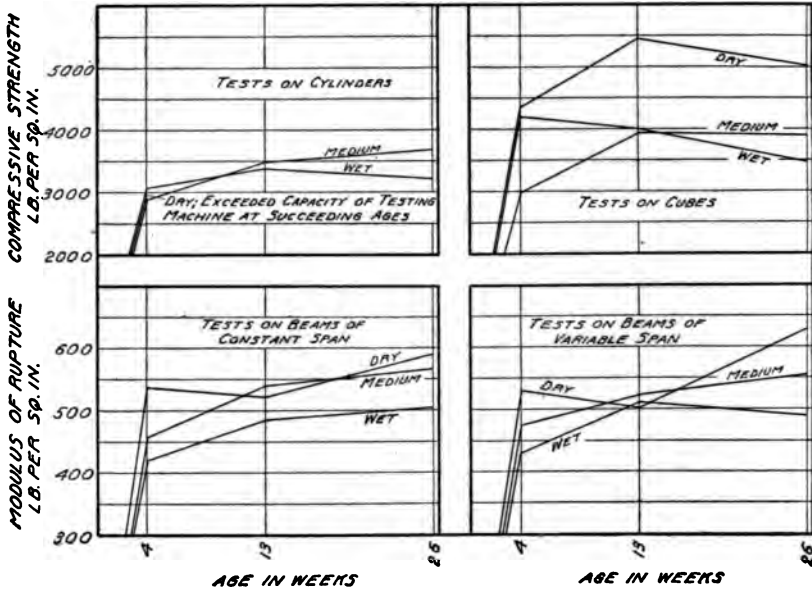


FIG. 5.—Diagrams showing the effect of age and consistency on the strength of limestone concrete.

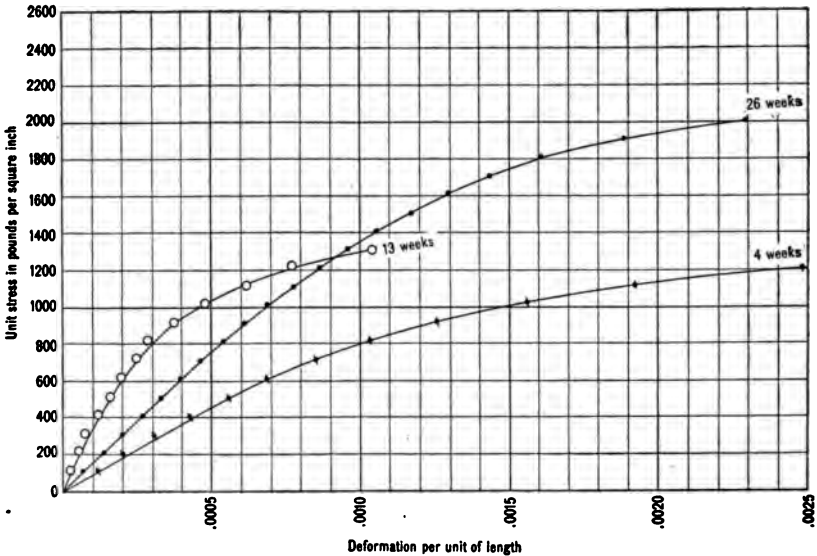


FIG. 6.—Characteristic compression-stress deformation diagrams, cinder concrete of medium consistency; ages 4, 13, and 26 weeks.

by weight, will show that this 21 per cent moisture forms as much 43 per cent of the total amount of water, including moisture, the necessary to bring the concrete to the desired consistency. Ded

ing this 43 per cent moisture from the total percentage of water leaves about 12 per cent of the total weight of the dry material as the weight of the water added plus the weight of the moisture in the sand. This does not differ so very much from the percentage of water used for the other aggregates. As already indicated, it would seem that the influence of the water present in the stone or cinders and even for usual values of 3 to 4 per cent in the sand does not influence the consistency as greatly as does the same weight of water when added to the batch.

Column 6 of the table gives the consistency of the concrete and must be compared with the definitions of wet, medium, and damp concrete already given (p. 20).

Columns 7, 8, and 9 give the dimensions of the beam, the span being kept constant at 12 feet.

Column 10 gives the total weight of the beam, which is obtained by weighing the beam on the testing machine. The error in weighing is in no case greater than 5 pounds in either direction. Column 11 gives the weight per cubic foot of the beam.

Column 12 gives the unit elongation of the lower fiber when the beam rests freely on a 12-foot span subjected only to its own weight and the weight of the deformeters. This value is obtained by first taking a reading for zero total deformation as already described (p. 23) and a second reading when the beam rests as above. This value is included for the reason that in all tests made up to the present time deformations due to applied load only were read. If it is desired to compare the present tests with others already made the unit elongation as given in column 14, which was measured at a load just previous to rupture, when decreased by the

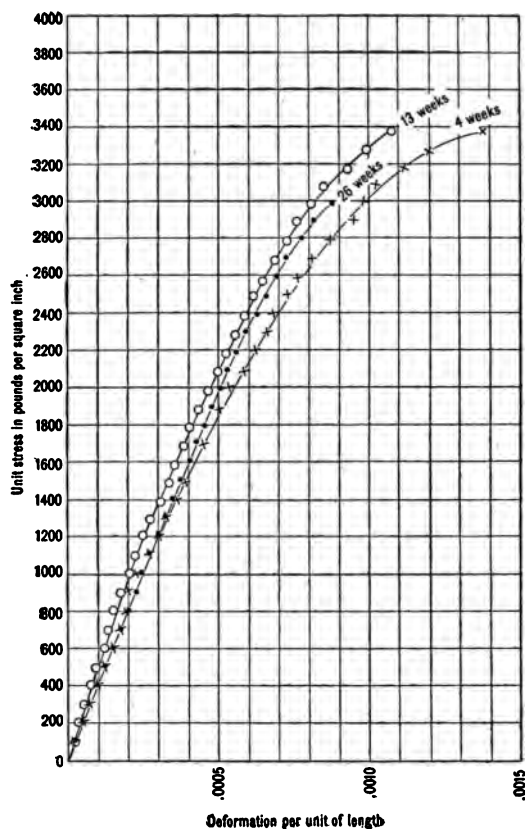


FIG. 7.—Characteristic compression-stress deformation diagrams, granite concrete of medium consistency; ages 4, 13, and 26 weeks.

value in column 12 will give the unit elongation at a point near rupture for the applied load alone.

Column 13 shows $\frac{M}{bd^2}$ (pounds per square inch) for the last load previous to failure. The relation of this value to the breaking value in column 19 is readily seen by comparison. In computing all the values of $\frac{M}{bd^2}$ given in these tables the nominal values 8 inches and 11

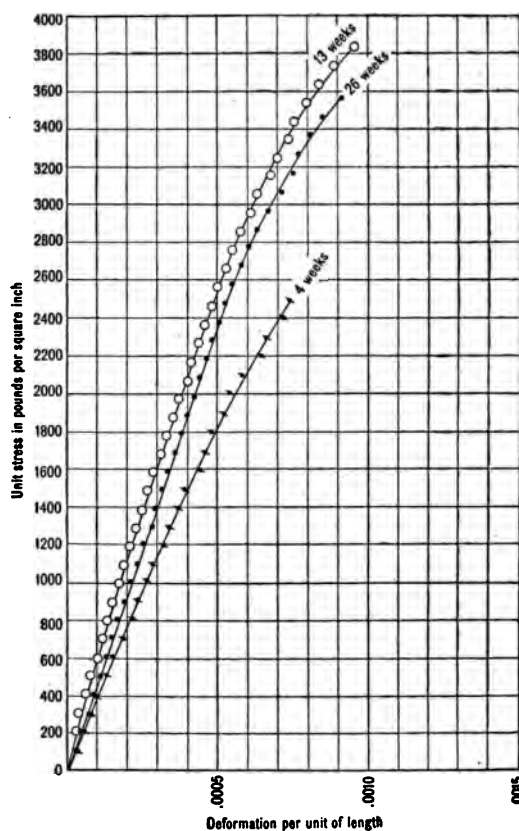


FIG. 8.—Characteristic compression-stress deformation diagrams, gravel concrete of medium consistency; ages 4, 13, and 26 weeks.

inches were used for the breadth (b) and the depth (d) of the beam.

Column 14 shows the unit elongation of the lower outer fiber for the load previous to rupture. An unsuccessful attempt was made to obtain an exact value for the unit elongation of the lower fiber at rupture, but it was found impossible to take a reading of the micrometers at the exact instant of the breaking of the beam. Just previous to the break the concrete in the lower fiber elongates so rapidly that it is impossible to revolve the micrometer fast enough to maintain contact with the rod. While the lower micrometers on both sides of the beam may be read as the beam breaks the values obtained are so erratic that they have

not been included in the tables of this bulletin.

The unit elongations reported under "Final deformeters" (columns 13, 14, and 15) in Table 8 are the values obtained at the last full set of readings preceding the breaking of the beam, and it must therefore be recognized that while they approximate the elongations at maximum load they are not absolute. Attention is called to the apparent

relation between the values in columns 13 and 14. Separating the aggregates into cinders on one hand and the three stone concretes on the other, the elongation seems to bear a direct relation to $\frac{M}{bd^2}$, or the load carried. This comparison, however, can not be made for the cinders, owing perhaps to the nonuniformity in the strength of the clinker itself.

Column 15 shows the position of the neutral axis for the load preceding failure. This is obtained from the usual assumption of proportionality between deformation and position of the neutral axis.

The maximum load applied at the third points of the span (column 16) excludes the weight of the deformaters. The corresponding $\frac{M}{bd^2}$ is shown in column 17.

Column 18 shows the $\frac{M}{bd^2}$ for the weight of the beam, taking into consideration the effect of the 6-inch overhang on each end and also the constant weight of the deformaters.

Column 19 shows the maximum total $\frac{M}{bd^2}$, which is equal to the sum of the values in columns 17 and 18.

Column 20 shows the modulus of rupture in pounds per square inch. These values were obtained by multiplying those in column 19 by 6. The method of computing the modulus of rupture should be emphasized. It is based on the assumption that the coefficients of elasticity in tension and compression are equal and constant and that

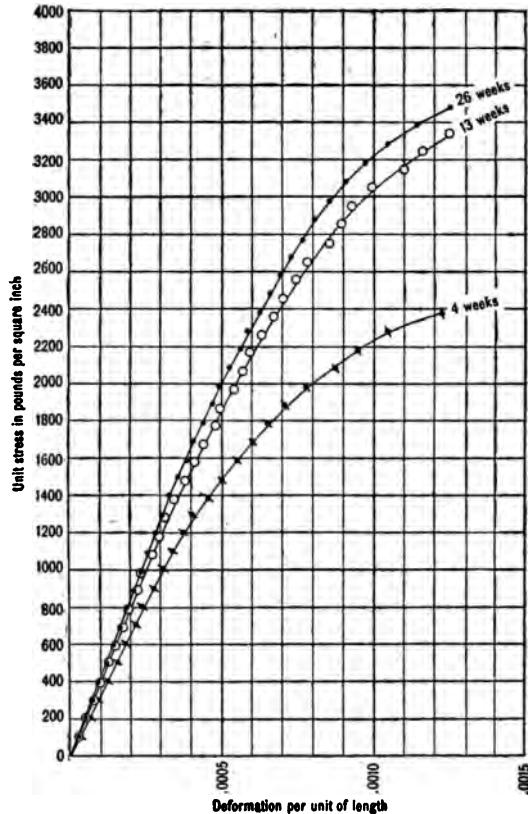


FIG. 9.—Characteristic compression-stress deformation diagrams, limestone concrete of medium consistency; ages 4, 13, and 26 weeks.

consequently the neutral axis remains in the center of the beam. An examination of the table shows, however, that the neutral axis actually varies from 30.4 to 63.0 per cent of the depth of the beam below the top.

Column 21 gives the distance of the break from the center of the beam, which in few cases is more than 1 foot.

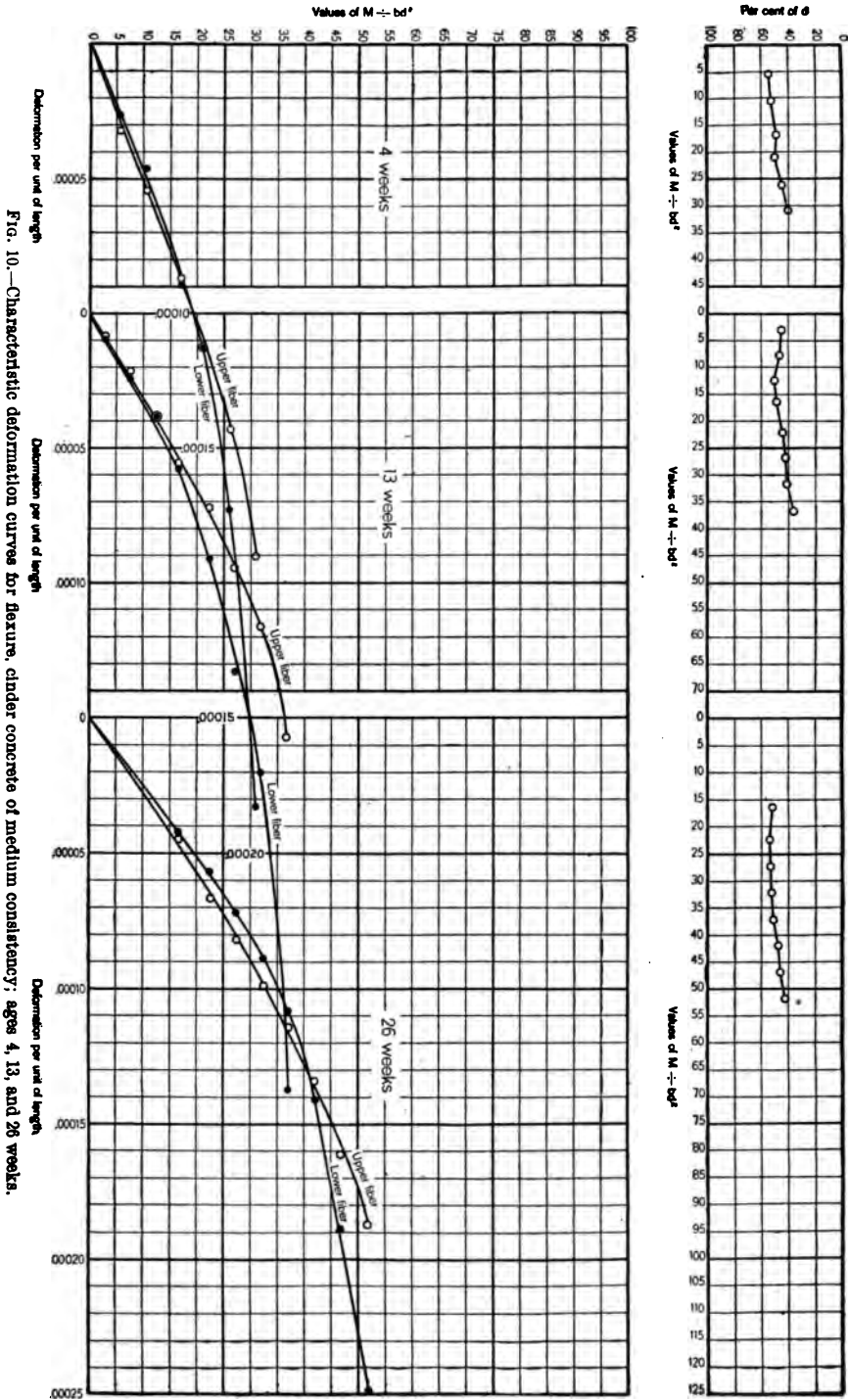


Fig. 10.—Characteristic deformation curves for flexure, cylinder concrete of medium consistency, ages 4, 13, and 26 weeks.

TABLE 8.—Tests of 13-foot concrete beams of constant 12-foot span.

TESTED AT FOUR WEEKS.

Register No.	Aggregate.	Proportion.		Water slat- stency. (per cent).	Dimensions of beam (inches).			Weight (pounds).		Unit elonga- tion, lower flange weight (own weight + defor- mers).	Final deformeters.			Maximum applied.		Own weight + deform- ers (cen- ter).	Maxi- mum total M bd ² (cen- ter).	Mod- ulus of rup- ture (6M bd ² in.- lb.).	Dis- tance of break from cen- ter (in.- ches).	
		Volume.	Weight.		Length in ex- cess of 13 feet.	Section.		Total.	Per cubic foot.		M bd ² (total).	Unit elonga- tion, lower flange fiber.	Post- tion neu- tral axis.	Load.						
						Wide.	Deep.													
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
18.	Cinder.	1:2.5.06	1:2.02:2.38	21.6	Wet.	0	8 1/2	11	940	117.4	0.000022	25.95	0.000200	42.5	510	12.54	17.10	29.64	178	37
19.	do.	1:2.5.06	1:2.02:2.38	21.8	do.	0	8	11	960	120.5	.000096	31.46	.000299	39.2	560	13.80	17.57	31.46	189	4
21.	do.	1:2.5.06	1:2.02:2.38	21.6	do.	0	8	11	950	119.3	.000108	21.37	.000188	43.8	360	8.93	17.40	26.33	158	11
Average									950	119.1	.000099	26.26	.000222	41.8	477	11.79	17.36	29.14	175	
24.	do.	1:2.5.06	1:2.02:2.38	19.4	Med.		8	11	910	114.3	.000096	35.57	.000430	35.0	760	18.85	16.72	35.57	213	2
28.	do.	1:2.06:5.40	1:2.07:2.54	20.4	do.		8	11	900	112.9	.000100	30.43	.000263	43.9	640	15.87	16.55	32.42	195	0
29.	do.	1:2.06:5.40	1:2.07:2.54	20.4	do.		8	11	920	115.6	.000089	30.77	.000283	40.3	560	13.88	16.89	30.77	185	3
Average									910	114.3	.000095	32.26	.000335	39.7	653	16.20	16.72	32.92	198	
37.	do.	1:2.5.19	1:2.01:2.44	19.0	Damp.		8 1/2	11	920	111.9	.000110	29.84	.000329	38.0	620	14.90	16.38	31.28	188	2
38.	do.	1:2.5.19	1:2.01:2.44	19.0	do.		8	11 1/2	940	115.5	.000125	29.75	.000374	36.2	660	15.65	16.47	32.12	193	18
39.	do.	1:2.5.19	1:2.01:2.44	19.0	do.		8	11 1/2	940	115.1	.000067	35.27	.000377	37.3	780	18.42	16.85	35.27	212	6
Average									933	114.2	.000111	31.62	.000360	37.2	687	16.32	16.57	32.89	198	
53.	Granite.	1:2.4	1:2.01:3.82	9.2	Wet.		8 1/2	11 1/2	1,220	150.2	.000024	58.38	.000067	63.5	1,840	44.26	21.34	65.60	394	13
54.	do.	1:2.4	1:2.01:3.82	9.0	do.		7 1/2	11 1/2	1,170	144.8	.000034	58.37	.000094	43.8	1,710	40.86	20.38	61.24	367	6
55.	do.	1:2.4	1:2.01:3.82	9.0	do.		8	11	1,170	146.7	.000022	60.58	.000079	52.6	1,590	39.43	21.15	60.58	393	0
Average									1,187	147.2	.000027	59.11	.000080	53.3	1,713	41.52	20.96	62.47	375	
51.	do.	1:2.4	1:2.01:3.82	7.3	Med.		8	11 1/2	1,190	147.5	.000028	76.04	.000120	49.3	2,470	59.88	21.01	80.89	485	18
64.	do.	1:2.4	1:2.01:3.82	8.4	do.		8 1/2	11 1/2	1,190	147.3	.000031	78.73	.000128	46.0	2,370	57.04	21.09	78.73	472	8
65.	do.	1:2.4	1:2.01:3.82	8.4	do.		8	11 1/2	1,240	153.8	.000028	68.39	.000067	49.1	2,320	56.23	21.85	78.08	468	19
Average									1,207	148.5	.000029	74.39	.000115	48.1	2,387	57.92	21.32	79.23	475	
72.	do.	1:2.4	1:2.01:3.82	6.9	Damp.		7 1/2	10 1/2	1,160	148.3	.000018	72.20	.000103	90.4	2,400	60.88	21.47	82.35	494	8
73.	do.	1:2.4	1:2.01:3.82	6.9	do.		8	11 1/2	1,220	149.8	.000029	67.02	.000130	43.5	2,340	55.46	21.04	76.50	449	2
78.	do.	1:2.4	1:2.01:3.82	6.9	do.		8	11 1/2	1,220	150.8	.000024	86.94	.000135	50.6	2,800	69.37	21.27	90.54	543	8
Average									1,200	149.6	.000024	75.39	.000119	51.5	2,543	61.87	21.26	83.13	499	

RESULTS OF TESTS.

87

88.....	Gravel...	1:2.4	1:2.01:4.10	9.5 Wet...	1:110	139.5	.000025	66.00	.000006	52.9	1,850	45.87	20.13	66.00	396	12
89 ^a	do.	1:2.4	1:2.01:4.10	9.5 do.	1,150	142.6	.000028	58.58	.000088	46.4	1,810	44.02	20.42	64.44	387	8
90.....	do.	1:2.4	1:2.01:4.10	9.7 do.	1,130	141.1	.000027	62.79	.000002	49.7	1,830	44.95	20.27	65.22	391	...
Average					1,130	142.4	.000025	69.69	.000090	50.5	2,420	59.12	20.34	79.46	477	16
100.....	do.	1:2.4	1:2.01:4.10	8.6 Med.	1,130	137.8	.000028	67.16	.000095	47.2	2,380	55.97	19.42	75.39	452	1
101.....	do.	1:2.4	1:2.01:4.10	8.6 do.	1,160	145.5	.000023	70.85	.000100	50.0	2,000	49.77	21.06	70.83	425	15
102.....	do.	1:2.4	1:2.01:4.10	9.0 do.	1,143	141.2	.000025	69.23	.000095	49.2	2,267	54.95	20.27	75.23	451	...
Average					1,110	139.3	.000023	61.04	.000088	49.0	2,050	50.83	20.13	70.96	428	7
112.....	do.	1:2.4	1:2.01:4.10	7.6 Damp.	1,158	142.9	.000021	59.37	.000082	47.3	2,010	48.72	20.35	69.07	414	6
113.....	do.	1:2.4	1:2.01:4.10	7.6 do.	1,110	140.6	.000035	62.68	.000109	41.8	2,050	52.20	20.67	72.87	437	0
115.....	do.	1:2.4	1:2.01:4.10	7.6 do.	1,123	140.9	.000026	61.03	.000093	46.0	2,037	50.58	20.38	70.97	426	...
Average					1,170	145.0	.000032	69.16	.000119	47.7	2,390	58.13	20.75	73.88	473	8
128.....	Limestone.	1:2.4	1:2.01:3.91	10.8 Wet.	1,150	139.1	.000023	66.29	.000101	53.2	2,010	46.76	19.53	66.29	398	8
129.....	do.	1:2.4	1:2.01:3.91	10.8 do.	1,170	142.0	.000026	56.64	.000084	50.9	1,990	46.14	19.78	65.92	386	5
130.....	do.	1:2.4	1:2.01:3.91	11.0 do.	1,163	142.0	.000027	64.03	.000101	50.6	2,130	50.34	20.02	70.36	422	...
Average					1,170	143.2	.000028	77.13	.000127	51.4	2,390	56.84	20.29	77.13	463	6
141.....	do.	1:2.4	1:2.01:3.91	10.0 Med.	1,170	146.1	.000028	69.70	.000114	49.1	2,030	49.77	20.91	70.68	424	15
142.....	do.	1:2.4	1:2.01:3.91	10.0 do.	1,170	147.8	.000032	71.05	.000110	51.4	2,390	59.72	21.32	81.04	486	3
143.....	do.	1:2.4	1:2.01:3.91	10.0 do.	1,170	145.7	.000029	72.63	.000117	50.6	2,270	55.44	20.84	76.28	458	...
Average					1,170	144.2	.000028	87.32	.000125	52.6	2,270	70.45	20.45	86.90	581	5
150.....	do.	1:2.4	1:2.01:3.91	8.4 Damp.	1,140	143.2	.000027	80.64	.000136	45.5	2,800	69.42	20.64	81.06	540	5
151.....	do.	1:2.4	1:2.01:3.91	8.4 do.	1,150	143.5	.000038	79.66	.000142	48.0	2,500	61.28	20.58	81.86	491	15
152.....	do.	1:2.4	1:2.01:3.91	8.4 do.	1,153	143.6	.000030	82.54	.000134	48.7	2,830	69.05	20.56	89.61	537	...
Average																

^a Accidentally broken before test.

TABLE 8.—Tests of 13-foot concrete beams of constant 12-foot span—Continued.

TESTED AT THIRTEEN WEEKS.

Register No.	Aggregate.	Proportion.		Water (per cent).	Consistency.	Dimensions of beam (inches).			Weight (pounds).		Unit elongation, lower outer fiber (own weight + deformers).	Final deformeters.					Maximum applied.		Own weight + defor- mers (con- ter).	Maxi- mum total M bd ² (con- ter).	Mod- ulus of rup- ture 6M bd ² (in- ch- es).	Dis- tance of break from cen- ter (in- ch- es).
		Volume.	Weight.			Length in excess of 13 feet.	Section.		Total.	Per cubic foot.		M bd ² (total).	Unit elonga- tion, lower outer fiber.	Posi- tion, neu- tral axis.	Load.	M bd ² (con- ter).						
							Wide.	Deep.														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21		
2	Cinders...	1:2.4.86	1:2.02:2.29	22.15	Wet...		8	11 ³ / ₈	960	118.4	0.00042	36.16	0.00142	47.8	890	21.33	16.99	38.32	230	15		
8	do.	1:2.4.79	1:2.02:2.25	22.3	do.		8	11 ³ / ₈	940	116.6	.00053	36.72	.00200	41.8	1,010	24.48	16.85	41.33	248	14		
9	do.	1:2.4.79	1:2.02:2.25	22.0	do.		8	11 ³ / ₈	930	115.3	.00066	36.80	.00275	37.4	980	23.76	16.68	40.44	243	21		
Average									943	116.8	.00054	36.56	.00206	42.3	960	23.19	16.84	40.03	240			
3	Cinders...	1:2.5.13	1:2.02:2.41	21.4	Med...		8	11 ³ / ₈	920	114.2	.00051	41.72	.00284	37.6	1,180	28.61	16.51	45.12	271	10		
33	do.	1:2.5.21	1:2.01:2.45	21.0	do.		8	11 ³ / ₈	930	114.8	.00073	32.39	.00293	36.9	700	17.16	16.70	33.86	203	9		
34	do.	1:2.5.21	1:2.01:2.45	20.0	do.		8 ¹ / ₂	11 ³ / ₈	930	114.4	.00058	36.51	.00287	35.4	830	19.96	16.55	36.51	219	2		
Average									923	114.5	.00061	36.87	.00288	36.6	903	21.91	16.59	38.50	231			
40	Cinders...	1:2.5.19	1:2.01:2.44	19.0	Damp.		8 ¹ / ₂	11 ³ / ₈	940	114.3	.00062	35.63	.00238	38.8	890	20.93	16.35	37.28	224	19		
41	do.	1:2.5.19	1:2.01:2.44	19.0	do.		8	11 ³ / ₈	940	116.8	.00073	36.72	.00320	36.0	930	22.54	16.85	39.39	236	15		
42	do.	1:2.5.19	1:2.01:2.44	18.9	do.		8	11 ³ / ₈	930	115.9	.00091	32.82	.00292	33.2	780	19.12	16.87	35.99	216	3		
Average									937	115.7	.00075	34.89	.00283	36.0	867	20.86	16.69	37.55	225			
56	Granite...	1:2.4	1:2.01:3.82	8.7	Wet...		8	11 ³ / ₈	1,200	149.1	.00023	68.09	.00078	52.6	2,310	55.99	21.18	77.17	463	16		
57	do.	1:2.4	1:2.01:3.82	8.7	do.		8	11 ³ / ₈	1,200	149.7	.00026	89.08	.00129	48.3	2,700	67.66	21.42	89.08	534	3		
58	do.	1:2.4	1:2.01:3.82	9.0	do.		8 ¹ / ₂	11 ³ / ₈	1,200	148.7	.00028	78.66	.00131	44.1	2,600	63.25	21.25	84.50	507	6		
Average									1,200	149.2	.00026	78.81	.00113	48.3	2,567	62.30	21.28	83.58	501			
68	Granite...	1:2.4	1:2.01:3.82	8.2	Med...		8 ¹ / ₂	11 ³ / ₈	1,240	149.2	.00023	74.10	.00096	50.0	2,710	62.34	20.73	83.07	498	18		
69	do.	1:2.4	1:2.01:3.82	8.2	do.		8	11 ³ / ₈	1,240	151.9	.00026	86.12	.00119	45.7	3,120	74.20	21.44	95.64	574	5		
70	do.	1:2.3.97	1:2.01:3.78	8.6	do.		8 ¹ / ₂	11 ³ / ₈	1,230	145.0	.00021	80.50	.00111	48.8	3,140	66.68	19.70	89.38	536	4		
Average									1,233	148.7	.00023	80.24	.00109	48.2	2,990	68.74	20.62	89.36	536			
79	Granite...	1:2.4	1:2.01:3.82	6.9	Damp.		8 ¹ / ₂	11	1,160	144.5	.00032	86.76	.00160	44.0	3,050	75.03	20.82	95.85	575	16		
80	do.	1:2.4	1:2.01:3.82	7.0	do.		8 ¹ / ₂	11 ³ / ₈	1,200	146.9	.00024	95.04	.00162	43.7	3,400	80.87	20.78	101.65	611	9		
81	do.	1:2.4	1:2.01:3.82	7.0	do.		8	11 ³ / ₈	1,160	143.9	.00024	98.08	.00155	47.1	3,200	77.57	20.51	98.08	588	0		
Average									1,173	145.1	.00027	94.57	.00159	44.9	3,217	77.82	20.70	98.53	591			

RESULTS OF TESTS.

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91.	Gravel.	1:2.4	1:2.01:4.10	9.7	Wet.	74½	11½	1,160	141.9	.000017	57.17	.000062	52.6	2,000	46.73	19.76	66.51	399	6
92.	do.	1:2.4	1:2.01:4.10	9.9	do.	8	11	1,160	145.2	.000023	50.74	.000057	54.1	1,410	34.96	20.98	55.94	336	24
93.	do.	1:2.4	1:2.01:4.10	9.9	do.	8	11½	1,170	143.7	.000026	57.91	.000081	46.6	1,990	47.17	20.22	67.39	404	11
Average								1,163	143.6	.000022	55.27	.000067	51.1	1,800	42.95	20.33	63.28	380	...
103	Gravel.	1:2.4	1:2.01:4.10	9.0	Med.	8½	10½	1,170	146.5	.000021	70.62	.000082	55.5	2,330	57.73	20.86	75.59	472	14
104.	do.	1:2.4	1:2.01:4.10	9.0	do.	8	11½	1,150	143.6	.000024	76.55	.000112	45.9	2,430	56.34	20.21	79.55	477	8
105.	do.	1:2.4	1:2.01:4.10	9.0	do.	74½	11½	1,140	143.3	.000021	80.24	.000106	51.9	2,440	60.14	20.10	80.24	481	2
Average								1,153	144.5	.000022	76.80	.000100	51.	2,400	59.07	20.39	79.46	477	...
116	Gravel.	1:2.4	1:2.01:4.10	7.6	Damp.	8½	10½	1,140	142.7	.000026	80.81	.000132	45.5	2,400	61.71	20.35	82.06	492	4
117.	do.	1:2.4	1:2.01:4.10	8.0	do.	8	10½	1,150	145.0	.000025	81.37	.000122	48.2	2,430	60.69	20.68	81.37	488	3
118.	do.	1:2.4	1:2.01:4.10	8.1	do.	74½	10½	1,120	144.1	.000026	73.80	.000105	46.0	2,400	63.10	21.05	84.15	515	24
Average								1,137	143.9	.000027	78.66	.000120	46.6	2,400	61.83	20.69	82.53	495	...
131	Limestone	1:2.4	1:2.01:3.91	11.0	Wet.	8	11½	1,190	147.6	.000028	66.65	.000096	46.5	2,200	54.79	20.41	75.20	451	6
132.	do.	1:2.4	1:2.01:3.91	11.0	do.	74½	11	1,170	147.7	.000026	80.93	.000116	49.3	2,760	68.97	20.70	86.67	538	10
133.	do.	1:2.4	1:2.01:3.91	11.0	do.	8	11½	1,180	146.6	.000024	68.72	.000094	48.6	2,400	58.18	20.24	78.42	471	19
Average								1,180	147.3	.000026	72.77	.000102	49.	2,473	60.65	20.45	81.10	487	...
126	Limestone	1:2.4	1:2.01:3.91	10.4	Med.	8	11½	1,150	143.5	.000025	86.35	.000142	44.6	2,830	69.38	19.97	86.35	536	0
127.	do.	1:2.4	1:2.01:3.91	10.4	do.	8	11½	1,200	146.4	.000028	94.44	.000124	50.4	3,180	74.54	19.90	94.44	567	3
140.	do.	1:2.4	1:2.01:3.91	10.0	do.	74½	11½	1,170	146.1	.000018	76.11	.000096	56.6	2,710	66.70	20.24	86.44	519	10
Average								1,173	145.3	.000023	87.63	.000121	50.5	2,907	70.04	20.04	90.08	541	...
153	Limestone	1:2.4	1:2.01:3.91	8.4	Damp.	8	10½	1,150	144.0	.000026	82.30	.000155	44.5	2,620	66.47	20.66	87.13	523	12
154.	do.	1:2.4	1:2.01:3.91	8.4	do.	74½	10½	1,150	146.1	.000032	82.00	.000136	46.3	2,430	61.41	20.69	82.00	492	22
155.	do.	1:2.4	1:2.01:3.91	8.4	do.	8	10½	1,160	146.3	.000034	91.32	.000138	48.5	2,820	70.72	20.60	91.32	548	15
Average								1,153	145.5	.000031	85.21	.000143	46.4	2,623	66.20	20.62	86.82	521	...

TABLE 8.—Tests of 13-foot concrete beams of constant 12-foot span—Continued.

TESTED AT TWENTY-SIX WEEKS.

Register No.	Aggregate.	Proportion.		Water (per cent).	Con-sist-ency.	Dimensions of beam (inches).			Weight (pounds).		Unit elongation, lower outer fiber (own weight + deformation).	Final deformeters.			Maximum applied.		Own weight + deformation (center).	Maximum total deformation (center).	Mod-ulus of rup-ture (center).	Dis-tance of break from cen-ter (inches).
		Volume.	Weight.			Length in ex-cess of 13 feet.	Section.	Wide.	Deep.	Total.		Per cubic foot.	M bd ² (total).	Unit elongation lower outer fiber.	Post-neutral axis.	Load.					M bd^{2} (center).
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
12	Cinder	1:2.4.79	1:2.02:2.25	22.4	Wet.	11.1 ^a	8	11.1 ^a	930	115.9	0.00045	40.78	0.000216	44.0	1,020	25.01	16.26	41.27	248	5
15	do.	1:2.4.79	1:2.02:2.25	22.4	do.	11.1 ^a	8	11.1 ^a	900	114.2	0.00045	36.60	0.00146	47.9	950	24.00	16.31	40.40	242	11
16	do.	1:2.5.06	1:2.02:2.38	21.3	do.	11.1 ^a	8 ^{1/2}	11.1 ^a	910	112.8	0.00047	40.13	0.00186	42.6	1,050	23.54	15.80	41.34	248	2
Average									913	114.3	0.00046	39.17	0.00183	44.8	1,007	24.88	16.12	41.00	246	
5	Cinder	1:2.4.79	1:2.02:2.25	21.7	Med.	11.1 ^a	8	11.1 ^a	940	117.2	0.00042	51.73	0.00240	42.9	1,440	35.30	16.43	51.73	310	6
6	do.	1:2.4.79	1:2.02:2.25	21.7	do.	11.1 ^a	8	11.1 ^a	930	116.0	0.00041	42.00	0.00180	43.5	1,210	29.67	16.26	45.93	276	10
35	do.	1:2.5.21	1:2.01:2.45	20.0	do.	11.1 ^a	8	11.1 ^a	930	116.1	0.00051	40.78	0.00371	34.0	1,000	24.52	16.26	46.78	245	4
Average									933	116.4	0.00045	44.84	0.00297	40.1	1,217	29.83	16.32	46.15	277	
43	Cinder	1:2.5.19	1:2.01:2.44	19.0	Damp.	11.1 ^a	8 ^{1/2}	11.1 ^a	910	111.3	0.00049	39.23	0.00265	40.8	1,150	27.35	15.45	42.80	237	6
44	do.	1:2.5.19	1:2.01:2.44	19.0	do.	11.1 ^a	8 ^{1/2}	11.1 ^a	920	114.0	0.00047	40.15	0.00290	38.2	1,040	25.21	15.91	41.12	247	6
45	do.	1:2.5.19	1:2.01:2.44	18.5	do.	11.1 ^a	8 ^{1/2}	11.1 ^a	910	111.8	0.00049	39.67	0.00266	38.5	1,050	25.26	15.62	40.88	245	4
Average									913	112.4	0.00048	39.68	0.00277	39.2	1,080	25.94	15.66	41.60	250	
59	Granite.	1:2.4	1:2.01:3.82	9.0	Wet.	11.1 ^a	8 ^{1/2}	11.1 ^a	1,220	145.2	0.00021	86.94	0.00132	45.8	3,000	67.52	19.42	86.94	532	22
60	do.	1:2.4	1:2.01:3.82	8.8	do.	11.1 ^a	8 ^{1/2}	11.1 ^a	1,230	151.9	0.00022	92.76	0.00137	47.1	3,000	71.92	20.84	92.76	557	3
61	do.	1:2.4	1:2.01:3.82	9.0	do.	11.1 ^a	8 ^{1/2}	11.1 ^a	1,230	150.3	0.00019	44.47	0.00060	48.5	3,000	30.92	20.68	51.60	310	1
Average									1,227	149.1	0.00021	89.85	0.00134	46.4	3,000	69.72	20.31	89.85	539	
71	Granite.	1:2.3.97	1:2.01:3.78	8.6	Med.	11.1 ^a	8 ^{1/2}	11.1 ^a	1,250	149.4	0.00021	88.39	0.00114	48.1	3,170	72.16	20.11	92.27	554	8
74	do.	1:2.4	1:2.01:3.82	8.4	do.	11.1 ^a	8	11.1 ^a	1,220	150.5	0.00023	92.60	0.00141	44.3	3,280	78.62	20.68	90.30	596	15
75	do.	1:2.4	1:2.01:3.82	8.4	do.	11.1 ^a	8	11.1 ^a	1,200	147.0	0.00021	91.24	0.00142	46.5	3,000	71.11	20.13	91.24	547	2
Average									1,223	149.0	0.00022	90.74	0.00132	46.3	3,150	73.96	20.31	94.27	566	
82	Granite.	1:2.4	1:2.01:3.82	7.0	Damp.	11.1 ^a	8	11.1 ^a	1,190	147.5	0.00019	105.25	0.00161	46.9	3,500	84.84	20.41	105.25	631	19
83	do.	1:2.4	1:2.01:3.82	7.0	do.	11.1 ^a	8 ^{1/2}	11.1 ^a	1,190	146.1	0.00023	92.74	0.00147	44.2	3,350	80.87	20.33	101.20	607	15
84	do.	1:2.4	1:2.01:3.82	7.1	do.	11.1 ^a	8 ^{1/2}	11.1 ^a	1,230	146.9	0.00021	99.76	0.00166	44.3	3,630	82.86	19.85	102.71	616	4
Average									1,203	146.8	0.00021	96.25	0.00158	45.1	3,493	82.86	20.20	103.05	618	

94.....	Gravel....	1:2:4	1:2.01:4.10	9.9 Wet...	8 $\frac{1}{2}$	11 $\frac{1}{16}$	1,150	136.4	.000021	63.55	.000076	53.2	2,500	56.45	18.39	74.84	449	14
95.....	do.....	1:2:4	1:2.01:4.10	9.9 do...	8 $\frac{1}{2}$	11 $\frac{1}{16}$	1,140	139.0	.000024	65.82	.000060	48.0	2,000	46.89	18.93	65.82	395	14
96.....	do.....	1:2:4	1:2.01:4.10	9.9 do...	8 $\frac{1}{2}$	11 $\frac{1}{16}$	1,170	140.5	.000021	76.82	.000069	49.1	2,500	57.70	19.12	76.82	401	14
Average							1,153	138.6	.000022	68.73	.000088	50.1	2,333	53.68	18.81	72.49	435	...
106.....	Gravel....	1:2:4	1:2.01:4.10	9.1 Med...	8	11 $\frac{1}{16}$	1,140	142.1	.000026	81.10	.000107	47.5	2,900	71.10	19.80	90.90	545	4
107.....	do.....	1:2:4	1:2.01:4.10	9.1 do...	8 $\frac{1}{2}$	11 $\frac{1}{16}$	1,150	138.0	.000023	76.50	.000067	47.7	2,900	66.94	18.80	85.74	514	1
108.....	do.....	1:2:4	1:2.01:4.10	9.0 do...	8 $\frac{1}{16}$	11 $\frac{1}{8}$	1,160	142.7	.000019	79.88	.000109	47.5	2,550	63.73	19.76	83.49	501	14
Average							1,150	140.9	.000023	79.16	.000104	47.6	2,817	67.26	19.45	86.71	520	...
119.....	Gravel....	1:2:4	1:2.01:4.10	8.1 Damp...	8 $\frac{1}{2}$	10 $\frac{1}{16}$	1,140	141.5	.000021	81.68	.000102	50.0	2,750	67.91	19.94	87.85	527	5
120.....	do.....	1:2:4	1:2.01:4.10	8.1 do...	8 $\frac{1}{2}$	11 $\frac{1}{16}$	1,140	140.7	.000023	68.54	.000103	47.8	2,370	57.80	19.72	77.58	465	3
121.....	do.....	1:2:4	1:2.01:4.10	8.1 do...	8 $\frac{1}{16}$	11	1,140	141.8	.000021	a 44.47	a .000062	a 45.5	a 1,450	a 35.67	19.87	a 55.54	a 333	9
Average							1,140	141.3	.000022	75.11	.000102	48.9	2,560	62.80	19.84	82.72	496	...
134.....	Limestone	1:2:4	1:2.01:3.91	11.0 Wet...	8 $\frac{1}{2}$	11 $\frac{1}{8}$	1,190	146.4	.000021	80.38	.000111	49.2	2,900	69.75	20.25	90.00	540	1
135.....	do.....	1:2:4	1:2.01:3.91	11.0 do...	8 $\frac{1}{16}$	11 $\frac{1}{4}$	1,190	144.5	.000025	a 55.09	a .000881	a 48.9	a 1,500	a 35.28	19.81	a 55.09	a 331	30
136.....	do.....	1:2:4	1:2.01:3.91	11.0 do...	8	11 $\frac{1}{16}$	1,190	145.8	.000024	79.22	.000125	44.7	2,500	59.26	19.96	79.22	475	14
Average							1,190	145.6	.000023	79.80	.000118	46.9	2,700	64.51	20.01	84.61	507	...
144.....	Limestone	1:2:4	1:2.01:3.91	10.0 Med...	8 $\frac{1}{2}$	11 $\frac{1}{8}$	1,180	144.0	.000021	91.54	.000119	53.0	3,000	71.00	19.94	91.54	549	9
145.....	do.....	1:2:4	1:2.01:3.91	10.0 do...	8	11 $\frac{1}{16}$	1,190	146.7	.000026	92.09	.000131	49.4	3,000	71.91	20.18	92.09	553	13
258.....	do.....	1:2:4	1:2.01:3.91	10.0 do...	8	11 $\frac{1}{16}$	1,190	145.1	.000021	90.07	.000109	50.0	3,400	79.69	19.74	99.43	597	23
Average							1,187	145.3	.000023	91.23	.000120	50.8	3,133	74.40	19.95	94.35	596	...
158.....	Limestone	1:2:4	1:2.01:3.91	8.6 Damp...	8	11 $\frac{1}{16}$	1,210	149.2	.000026	92.42	.000144	46.2	3,200	76.71	20.51	97.22	583	2
259.....	do.....	1:2:4	1:2.01:3.91	8.6 do...	8 $\frac{1}{16}$	11	1,200	149.4	.000023	a 45.48	a .000049	a 50.8	a 1,900	a 24.59	20.89	a 45.48	a 273	21
260.....	do.....	1:2:4	1:2.01:3.91	8.6 do...	8 $\frac{1}{16}$	11 $\frac{1}{4}$	1,210	147.3	.000019	90.70	.000111	48.8	3,360	79.04	20.13	96.17	595	1
Average							1,207	148.6	.000023	91.56	.000127	47.5	3,280	77.88	20.51	98.20	589	...

a Not included in average.

TABLE 9.—Tests of concrete beams of variable span.

TESTED AT FOUR WEEKS.

Register No.	Aggregate.	Proportion.		Water (per cent).	Con- crete- ness.	Dimensions of beam.				Span (ft.).	Weight (pounds).			Final deformeters.			Maximum applied.		Own weight + de- for- mers (M bd ² (center)).	Maxi- mum M bd ² (center).	Modu- lus of rup- ture (M bd ² (center)).	Dis- tance of break from center (inches).
		Volume.	Weight.			Length.	Section (inches).		Total.		Per cubic foot.	M bd ² (total).	Unit elongation lower outer fiber.	Posi- tion neutral axis.	Load.	M bd ² (center).						
							Ft.	In.									Wide.	Deep.				
18.....	Cinder.....	1:2:5.06	1:2.02:2.38	21.6	Wet.....	9	7	8 ¹ / ₂	11	9	693	117.4	21.53	0.00235	32.6	1,400	21.53	9.37	30.90	185	.....
19.....	.....do.....	1:2:5.06	1:2.02:2.38	21.8	.....do.....	6	10	8	11	6	508	120.5	27.27	.000256	40.5	4,670	28.95	4.25	33.20	199	17
21.....	.....do.....	1:2:5.06	1:2.02:2.38	21.6	.....do.....	7	5	8	11	7	542	119.3	22.31	.000191	41.4	2,470	22.97	5.81	28.78	173	.....
Average.....	.....do.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	119.1	.....	.000227	38.2	.....	.....	.....	30.96	186	.....
24.....	Cinder.....	1:2:5.06	1:2.02:2.38	19.4	Med.....	6	8	8	11	6	467	114.3	32.23	.000284	38.5	5,520	34.22	4.08	38.30	220	.....
28.....	.....do.....	1:2.06:3.40	1:2.07:2.54	20.4	.....do.....	6	6	8	11	6	459	112.9	27.27	.000301	38.3	4,400	27.27	4.03	31.32	188	.....
29.....	.....do.....	1:2.06:3.40	1:2.07:2.54	20.4	.....do.....	6	9	8 ¹ / ₂	11	6	478	115.6	19.23	.000120	36.4	5,920	23.56	3.98	27.54	165	.....
Average.....	.....do.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	114.3	.....	.000235	37.7	.....	.....	.....	32.39	194	.....
37.....	Cinder.....	1:2:5.19	1:2.01:2.44	19.0	Damp.....	6	6	8 ¹ / ₂	11	6	460	111.9	26.44	.000297	36.9	4,400	26.44	4.01	30.45	183	7	
38.....	.....do.....	1:2:5.19	1:2.01:2.44	19.0	.....do.....	8	0	8	11 ¹ / ₂	7 ¹ / ₂	578	115.5	24.89	.000294	38.9	2,440	23.30	6.29	31.59	190	12
39.....	.....do.....	1:2:5.19	1:2.01:2.44	19.0	.....do.....	7	0	8	11 ¹ / ₂	6 ¹ / ₂	506	113.1	27.26	.000229	36.6	5,880	26.53	4.84	34.37	206	24
Average.....	.....do.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	114.2	.....	.000253	38.5	.....	.....	.....	32.14	193	.....
53.....	Granite.....	1:2:4	1:2.01:3.82	9.2	Wet.....	7	7	8 ¹ / ₂	11 ¹ / ₂	6 ¹ / ₂	712	150.2	52.61	.000093	43.8	7,950	59.76	6.04	65.80	395	0	
54.....	.....do.....	1:2:4	1:2.01:3.82	9.0	.....do.....	7	0	7 ¹ / ₂	11 ¹ / ₂	6 ¹ / ₂	630	144.8	52.26	.000079	51.5	8,000	52.72	5.88	65.80	394	12
55.....	.....do.....	1:2:4	1:2.01:3.82	9.0	.....do.....	6	6	8	11	6	585	144.9	40.58	.000075	47.6	9,000	55.79	5.20	60.99	366	.....
Average.....	.....do.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	146.6	.....	.000082	47.6	.....	.....	.....	64.13	385	.....
51.....	Granite.....	1:2:4	1:2.01:3.80	7.3	Med.....	8	0	8	11 ¹ / ₂	7	732	145.7	63.63	.000090	47.5	8,000	72.72	6.93	79.65	478	5	
64.....	.....do.....	1:2:4	1:2.01:3.82	8.4	.....do.....	7	2	8 ¹ / ₂	11 ¹ / ₂	6 ¹ / ₂	636	147.3	60.95	.000097	45.2	9,000	68.60	6.06	74.66	448	8
65.....	.....do.....	1:2:4	1:2.01:3.82	8.4	.....do.....	8	1	8 ¹ / ₂	11 ¹ / ₂	7	771	153.8	62.63	.000100	49.1	8,000	71.60	7.06	78.66	472	19
Average.....	.....do.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	148.9	.....	.000096	47.3	.....	.....	.....	77.66	466	.....
72.....	Granite.....	1:2:4	1:2.01:3.82	6.9	Damp.....	7	2	8	10 ¹ / ₂	6 ¹ / ₂	639	147.2	71.34	.000132	45.0	10,000	79.25	6.16	85.41	512	2	
73.....	.....do.....	1:2:4	1:2.01:3.82	6.9	.....do.....	6	8	8	11	6	626	149.8	74.38	.000129	45.0	13,000	80.58	5.59	85.97	516	5
78.....	.....do.....	1:2:4	1:2.01:3.82	6.9	.....do.....	7	2	8	11 ¹ / ₂	6 ¹ / ₂	673	150.8	74.90	.000125	44.7	11,000	82.39	6.12	88.51	531	24
Average.....	.....do.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	149.3	.....	.000129	44.9	.....	.....	.....	86.63	520	.....

88.	Gravel...	1:2:4	1:2.01:4.10	9.5	Wet..	7	6	8	11	7	640	139.5	46.49	.000073	44.8	6,000	55.79	6.73	62.52	375	16
89.	do.	1:2:4	1:2.01:4.10	9.5	do.	7	9	8 $\frac{1}{2}$	11 $\frac{1}{2}$	7	700	142.3	52.52	.000063	42.6	6,000	52.52	6.65	59.17	355	6
90.	do.	1:2:4	1:2.01:4.10	9.7	do.	7	2	8 $\frac{1}{2}$	11 $\frac{1}{2}$	6 $\frac{1}{2}$	634	142.6	45.62	.000063	47.7	7,000	53.22	5.87	59.09	355	6
Average.												141.5		.000076	45.0				60.26	362	
100.	Gravel...	1:2:4	1:2.01:4.10	8.6	Med..	7	10	8 $\frac{1}{2}$	11 $\frac{1}{2}$	7	687	142.4	62.72	.000097	44.1	8,390	75.17	6.59	81.76	491	8
101.	do.	1:2:4	1:2.01:4.10	8.6	do.	6	7	8 $\frac{1}{2}$	11 $\frac{1}{2}$	6 $\frac{1}{2}$	572	137.8	53.10	.000081	45.5	9,000	53.10	4.78	57.88	347	17
102.	do.	1:2:4	1:2.01:4.10	9.0	do.	7	9	8 $\frac{1}{2}$	11 $\frac{1}{2}$	7	692	145.5	63.86	.000105	39.1	7,000	63.86	6.85	70.66	424	16
Average.												141.9		.000094	42.9				70.10	421	
112.	Gravel...	1:2:4	1:2.01:4.10	7.6	Damp	7	1	8 $\frac{1}{2}$	11	6 $\frac{1}{2}$	605	139.3	61.04	.000114	43.6	8,000	61.04	5.71	66.75	400	14
113.	do.	1:2:4	1:2.01:4.10	7.6	do.	7	0	8	11	6 $\frac{1}{2}$	619	142.9	61.98	.000114	44.1	8,000	61.98	6.00	67.98	408	2
115.	do.	1:2:4	1:2.01:4.10	7.6	do.	6	6	8 $\frac{1}{2}$	11	6	555	140.6	84.57	.000129	40.0	11,000	84.57	4.91	86.48	537	5
Average.												140.9		.000119	42.6				74.74	448	
128.	Limestone	1:2:4	1:2.01:3.91	10.8	Wet..	7	2	8 $\frac{1}{2}$	11 $\frac{1}{2}$	6 $\frac{1}{2}$	645	145.0	60.82	.000101	50.0	8,600	65.84	5.96	71.80	431	7
129.	do.	1:2:4	1:2.01:3.91	10.8	do.	6	11	8	11 $\frac{1}{2}$	6	612	139.1	71.11	.000112	48.1	12,000	71.11	4.82	75.93	456	19
130.	do.	1:2:4	1:2.01:3.91	11.0	do.	6	11	8	11 $\frac{1}{2}$	6	623	142.0	57.96	.000105	43.2	10,930	63.34	4.79	68.13	409	3
Average.												142.0		.000106	47.4				71.95	432	
141.	Limestone	1:2:4	1:2.01:3.91	10.0	Med..	7	0	8 $\frac{1}{2}$	11 $\frac{1}{2}$	6 $\frac{1}{2}$	630	143.2	68.42	.000130	47.3	9,720	73.88	5.99	79.87	479	15
142.	do.	1:2:4	1:2.01:3.91	10.0	do.	7	9	8 $\frac{1}{2}$	11 $\frac{1}{2}$	7	698	146.8	63.86	.000102	50.0	8,000	72.98	6.91	79.89	479	9
143.	do.	1:2:4	1:2.01:3.91	10.0	do.	6	9	8	11 $\frac{1}{2}$	6	608	147.8	73.54	.000145	42.7	12,000	73.54	5.11	78.65	472	1
Average.												145.7		.000126	46.7				79.47	477	
150.	Limestone	1:2:4	1:2.01:3.91	8.4	Damp	6	11	8 $\frac{1}{2}$	11 $\frac{1}{2}$	6	623	144.2	84.18	.000138	44.5	15,000	90.19	4.97	93.16	571	14
151.	do.	1:2:4	1:2.01:3.91	8.4	do.	6	11	8	10 $\frac{1}{2}$	6	697	143.2	83.40	.000145	45.0	13,000	83.40	5.17	88.57	531	9
152.	do.	1:2:4	1:2.01:3.91	8.4	do.	7	9	8	10 $\frac{1}{2}$	7	686	143.5	63.84	.000120	46.8	8,000	73.24	7.00	82.29	494	16
Average.												143.6		.000134	45.4				88.67	532	

TABLE 9.—Tests of concrete beams of variable span—Continued.

TESTED AT THIRTEEN WEEKS.

Register No.	Aggregate.	Proportion.		Water (per cent).	Consistency.	Dimensions of beam.					Weight (pounds).			Final deformeters.			Maximum applied.			Own weight of de- formers (center).	Maximum of total rupture (center).	Dis- tance of break from cen- ter (inches).
		Volume.	Weight.			Length.	Section (inches).		Span (ft.).	Total.	Per cubic foot.	M bd ² (total).	Unit elongation, lower outer fiber.	Position, neu- tral axis.	Load.	M bd ² (center).						
							Ft.	In.									Wide.	Deep.				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
2.....	Cinder.....	1:2.4.86	1:2.02:2.29	22.15	Wet.....	7	9	8 $\frac{1}{2}$	11 $\frac{1}{8}$	7	572	118.4	31.87	0.000121	44.1	4,000	35.41	5.54	40.95	246	20	
3.....	do.....	1:2.4.79	1:2.02:2.25	22.3	do.....	7	8	8	11	7	554	116.6	29.75	.000165	40.8	3,600	33.47	5.72	39.19	235	11	
4.....	do.....	1:2.4.79	1:2.02:2.25	22.0	do.....	8	3	8	11 $\frac{1}{2}$	7 $\frac{1}{2}$	590	115.3	33.94	.000248	35.0	3,460	36.70	6.24	43.04	258	18	
Average.....												116.8		.000178	40.0				41.06	246		
3.....	Cinder.....	1:2.5.13	1:2.02:2.41	21.4	Med.....	7	4	8 $\frac{1}{2}$	11	6 $\frac{1}{2}$	519	114.2	33.57	.000178	41.3	4,800	36.62	4.73	41.35	248	19	
33.....	do.....	1:2.5.21	1:2.01:2.45	21.0	do.....	7	3	8 $\frac{1}{2}$	11 $\frac{1}{8}$	6 $\frac{1}{2}$	513	114.8	27.16	.000203	40.2	4,000	30.17	4.69	34.86	209	20	
34.....	do.....	1:2.5.21	1:2.01:2.45	20.0	do.....	6	8	8	11 $\frac{1}{2}$	6	477	114.4	33.93	.000340	30.9	5,600	33.93	4.07	38.00	228	12	
Average.....												114.5		.000240	37.5				38.07	228		
40.....	Cinder.....	1:2.5.19	1:2.01:2.44	19.0	Damp.....	8	1	8	11 $\frac{1}{8}$	7 $\frac{1}{2}$	584	114.3	33.55	.000275	36.8	3,200	33.55	6.36	39.91	239	4	
41.....	do.....	1:2.5.19	1:2.01:2.44	19.0	do.....	7	9	8	11	7	560	116.8	33.47	.000446	30.4	3,600	33.47	5.70	39.17	235	1	
42.....	do.....	1:2.5.19	1:2.01:2.44	18.9	do.....	6	9	8	11	6	483	115.9	29.75	.000276	36.9	5,200	32.23	4.15	36.38	218	10	
Average.....												115.7		.000332	34.7				38.40	231		
56.....	Granite.....	1:2.4	1:2.01:3.82	8.7	Wet.....	7	10	8 $\frac{1}{2}$	11 $\frac{1}{8}$	7	723	149.1	70.80	.000092	48.1	9,000	79.65	6.84	86.49	519	6	
57.....	do.....	1:2.4	1:2.01:3.82	8.7	do.....	6	9	8	11 $\frac{1}{8}$	6 $\frac{1}{2}$	623	149.7	74.38	.000098	48.6	12,700	78.72	5.29	84.01	504	0	
58.....	do.....	1:2.4	1:2.01:3.82	9.0	do.....	7	0	8 $\frac{1}{2}$	11 $\frac{1}{8}$	6 $\frac{1}{2}$	646	148.7	76.02	.000131	46.5	10,000	76.02	6.14	82.16	493	9	
Average.....												149.2		.000107	47.7				84.22	505		
68.....	Granite.....	1:2.4	1:2.01:3.82	8.2	Med.....	8	0	8 $\frac{1}{2}$	11 $\frac{1}{8}$	7 $\frac{1}{2}$	763	149.2	70.46	.000104	45.1	7,590	76.40	7.25	83.65	502	10	
69.....	do.....	1:2.4	1:2.01:3.82	8.2	do.....	6	11	8	11 $\frac{1}{8}$	6	690	151.9	79.39	.000126	43.1	14,000	79.39	4.96	84.35	506	14	
70.....	do.....	1:2.3.97	1:2.01:3.78	8.6	do.....	6	10	8 $\frac{1}{2}$	11 $\frac{1}{8}$	6	563	145.0	82.60	.000123	45.9	15,630	86.07	4.20	90.27	542	20	
Average.....												148.7		.000118	44.7				86.09	517		
79.....	Granite.....	1:2.4	1:2.01:3.82	6.9	Damp.....	7	10	8	11	7	699	144.5	83.68	.000129	46.5	10,000	82.98	6.96	98.94	600	21	
80.....	do.....	1:2.4	1:2.01:3.82	7.0	do.....	7	3	8 $\frac{1}{2}$	11 $\frac{1}{8}$	6 $\frac{1}{2}$	669	146.9	87.22	.000147	42.9	13,000	84.50	5.83	100.33	602	0	
81.....	do.....	1:2.4	1:2.01:3.82	7.0	do.....	6	6	7 $\frac{1}{2}$	10 $\frac{1}{8}$	6	580	143.9	82.14	.000147	44.2	14,000	88.46	5.26	93.72	562	5	
Average.....												145.1		.000140	44.5				98.00	598		

RESULTS OF TESTS.

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91.	Gravel	1:2:4	1:2.01:4.10	9.7	Wet	7	0	7 1/2	11 1/2	6 1/2	625	141.9	51.12	.000067	48.0	7,000	51.12	5.71	56.83	341	4
92.	do	1:2:4	1:2.01:4.10	9.9	do	8	6	8	11 1/2	8	758	145.2	60.60	.000088	46.4	5,570	67.52	8.95	76.47	459	2
93.	do	1:2:4	1:2.01:4.10	9.9	do	7	5	8	11 3/8	6 1/2	668	145.7	59.92	.000081	48.9	9,000	67.41	5.83	73.24	439	0
Average												143.6		.000079	47.8				68.85	413	
103.	Gravel	1:2:4	1:2.01:4.10	9.0	Med	7	8	8	11	7	690	146.5	74.38	.000121	42.2	8,000	74.38	7.05	81.43	489	21
104.	do	1:2:4	1:2.01:4.10	9.0	do	7	2	8	11 3/8	6 1/2	634	143.6	67.41	.000082	48.4	10,000	74.90	5.78	80.08	484	15
105.	do	1:2:4	1:2.01:4.10	9.0	do	6	8	8	11	6	585	143.3	74.38	.000116	45.1	12,000	74.38	5.05	79.43	477	22
Average												144.5		.000106	45.2				80.51	483	
116.	Gravel	1:2:4	1:2.01:4.10	7.6	Damp	6	10	8	11	6	599	142.7	68.19	.000159	38.0	12,000	74.39	5.01	79.40	476	8
117.	do	1:2:4	1:2.01:4.10	8.0	do	6	9	7 1/2	11 1/2	6	597	145.0	74.12	.000394	48.6	13,000	80.30	5.06	85.36	512	20
118.	do	1:2:4	1:2.01:4.10	8.1	do	8	6	8	10 1/2	8	732	144.1	63.42	.000082	48.4	5,960	75.60	9.05	84.65	508	6
Average												143.9		.000112	45.0				83.14	499	
131.	Limestone	1:2:4	1:2.01:3.91	11.0	Wet	6	11	8 1/2	11	6	633	147.6	73.24	.000101	49.5	13,000	79.35	5.12	84.47	507	22
132.	do	1:2:4	1:2.01:3.91	11.0	do	7	4	7 1/2	11 1/2	6 1/2	660	147.7	83.99	.000121	46.2	11,000	83.99	5.96	89.95	540	14
133.	do	1:2:4	1:2.01:3.91	11.0	do	8	1	8	11 3/8	7 1/2	734	146.6	62.91	.000095	46.1	6,950	72.88	7.91	80.79	485	16
Average												147.3		.000106	47.3				85.07	510	
126.	Limestone	1:2:4	1:2.01:3.91	10.4	Med	6	6	8	11	6	575	143.5	80.58	.000113	51.8	13,000	80.58	5.12	85.70	514	9
127.	do	1:2:4	1:2.01:3.91	10.4	do	6	9	8	11 1/2	6	623	146.4	83.89	.000127	48.3	14,000	83.89	5.11	89.00	534	0
140.	do	1:2:4	1:2.01:3.91	10.0	do	7	4	7 1/2	11	6 1/2	660	146.1	74.66	.000105	50.0	10,640	79.43	5.82	85.25	512	7
Average												145.3		.000115	50.0				86.65	520	
153.	Limestone	1:2:4	1:2.01:3.91	8.4	Damp	7	4	7 1/2	10 1/2	6 1/2	649	144.0	78.98	.000147	42.6	10,000	78.98	6.06	85.94	510	17
154.	do	1:2:4	1:2.01:3.91	8.4	do	8	4	7 1/2	11	7 1/2	737	146.1	76.53	.000137	44.8	7,000	76.53	7.99	84.62	507	3
155.	do	1:2:4	1:2.01:3.91	8.4	do	7	9	8 1/2	11	7	692	146.3	73.80	.000112	47.6	8,000	73.80	6.93	80.73	484	18
Average												145.5		.000132	45.0				83.43	501	

TABLE 9.—*Tests of concrete beams of variable span—Continued.*
TESTED AT TWENTY-SIX WEEKS.

Register No.	Aggregate.	Proportion.		Water (per cent).	Dimensions of beam.				Weight (pounds).			Final deformeters.			Maximum applied.		Own weight of beam (center).	Maximum total M (center).	Modulus of rupture (center).	Distance of break from center (inches).		
		Volume.	Weight.		Wet.	Length.		Section (inches).	Span (ft.).	Total.	Per cubic foot.	M (total).	Unit elongation lower outer fiber.	Position neutral axis.	Load.	M (center).						
						Ft.	In.														Wide.	Deep.
1		3	4	5	6																	
12.....	Cinder.....	12.4.79	1.2.02.2.25	22.4	Wet.....	6	11	8 ¹ / ₂	11 ¹ / ₂	6	405	115.9	39.52	0.000266	38.0	6,670	40.56	4.04	44.60	268	21	
13.....	.....do.....	12.4.79	1.2.02.2.25	22.4	..do..	7	5	8	10 ¹ / ₂	6 ¹ / ₂	513	114.2	35.67	.000171	44.2	5,000	39.63	4.80	44.43	267	21
16.....	.....do.....	12.5.06	1.2.02.2.38	21.3	..do..	6	8	7 ¹ / ₂	11	6	467	112.8	40.60	.000259	40.6	6,500	40.60	4.11	44.71	268	16
Average.....											114.3			.000232	40.9				44.58	268	....
5.....	Cinder.....	12.4.79	1.2.02.2.25	21.7	Med.....	7	0	8 ¹ / ₂	11 ¹ / ₂	6	506	117.2	48.31	.000232	43.5	6,500	48.31	4.75	53.06	318	11	
6.....	.....do.....	12.4.79	1.2.02.2.25	21.7	..do..	7	4	8 ¹ / ₂	11	6 ¹ / ₂	525	116.0	38.44	.000193	42.9	5,500	42.28	4.82	47.10	283	9
35.....	.....do.....	12.5.21	1.2.01.2.45	20.0	..do..	6	10	8	11	6	489	116.1	34.10	.000211	40.4	5,600	34.71	4.13	38.84	235	24
Average.....											116.4			.000212	42.3				46.33	278	....
43.....	Cinder.....	12.5.19	1.2.01.2.44	19.0	Damp	7	0	8 ¹ / ₂	11 ¹ / ₂	6 ¹ / ₂	400	111.3	41.48	.000327	39.0	5,600	42.24	4.68	46.92	282	17	
44.....	.....do.....	12.5.19	1.2.01.2.44	19.0	..do..	7	0	8 ¹ / ₂	11 ¹ / ₂	6 ¹ / ₂	405	114.0	37.26	.000264	39.2	5,350	39.60	4.67	44.57	267	3
45.....	.....do.....	12.5.19	1.2.01.2.44	18.5	..do..	6	10	8 ¹ / ₂	11 ¹ / ₂	6	478	111.8	39.22	.000280	38.1	6,500	39.22	3.94	43.16	259	14
Average.....											112.4			.000294	38.8				44.88	269	....
59.....	Granite.....	12.4	1.2.01.3.82	9.0	Wet.....	8	4	8 ¹ / ₂	11 ¹ / ₂	7 ¹ / ₂	782	145.2	81.42	.000124	47.8	8,000	81.42	7.87	89.29	526	0	
60.....	.....do.....	12.4	1.2.01.3.82	8.8	..do..	6	9	7 ¹ / ₂	11 ¹ / ₂	6	630	151.9	81.56	.000114	46.4	14,950	87.09	5.09	92.18	553	8
61.....	.....do.....	12.4	1.2.01.3.82	9.0	..do..	6	7	8	11 ¹ / ₂	6	623	150.3	78.78	.000121	45.8	13,550	82.11	5.33	87.44	525	19
Average.....											149.1			.000120	46.7				89.64	538	....
71.....	Granite.....	12.3.97	1.2.01.3.78	8.6	Med.....	7	2	8 ¹ / ₂	11 ¹ / ₂	6 ¹ / ₂	689	149.4	85.36	.000112	48.0	12,000	85.36	5.95	91.31	548	22	
74.....	.....do.....	12.4	1.2.01.3.82	8.4	..do..	7	9	8 ¹ / ₂	11 ¹ / ₂	7	727	150.5	89.18	.000132	45.0	10,000	89.18	7.02	96.20	577	15
75.....	.....do.....	12.4	1.2.01.3.82	8.4	..do..	6	8	8	11 ¹ / ₂	6	615	147.0	83.90	.000130	44.5	14,000	83.90	5.12	89.02	534	22
Average.....											149.0			.000125	46.8				92.18	553	....
82.....	Granite.....	12.4	1.2.01.3.82	7.0	Damp.	8	1	8 ¹ / ₂	11 ¹ / ₂	7 ¹ / ₂	740	147.5	85.13	.000123	47.1	8,900	94.70	8.09	102.79	617	16	
83.....	.....do.....	12.4	1.2.01.3.82	7.0	..do..	7	0	8 ¹ / ₂	11 ¹ / ₂	7	709	146.1	80.56	.000123	42.8	10,000	89.50	6.88	96.28	578	7
84.....do.....	12.4	1.2.01.3.82	7.1	..do..	6	10	8 ¹ / ₂	11 ¹ / ₂	6	647	146.9	87.22	.000132	45.8	15,550	90.42	5.06	95.48	573	16	
Average.....											146.8			.000126	45.2				98.22	586	

RESULTS OF TESTS.

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94.	Gravel...	1:2.4	1:2.01:4.10	9.9 Wet...	7	8	8 ¹⁰	11 ¹⁰	7	678	136.4	69.02	.000087	51.9	9,000	77.64	6.43	84.07	504	6	
95.	do...	1:2.4	1:2.01:4.10	9.9 ...do...	7	8	8 ¹⁰	11 ¹⁰	7	672	136.0	70.32	.000096	48.2	8,000	70.32	6.50	76.82	461	14	
96.	do...	1:2.4	1:2.01:4.10	9.9 ...do...	7	8	8 ¹⁰	11 ¹⁰	7	690	140.5	60.59	.000087	43.5	7,000	60.59	6.57	67.16	403	10	
Average.																					
106.	Gravel...	1:2.4	1:2.01:4.10	9.1 Med...	6	10	8	11 ¹⁰	6	599	142.1	67.42	.000094	47.6	12,000	73.55	4.96	78.51	471	17	
107.	do...	1:2.4	1:2.01:4.10	9.1 ...do...	6	8	8	11 ¹⁰	6	582	138.0	80.58	.000114	45.5	14,000	86.78	5.10	91.88	551	16	
108.	do...	1:2.4	1:2.01:4.10	9.0 ...do...	7	8	8	11 ¹⁰	7	684	142.7	63.63	.000090	45.9	7,920	72.00	6.84	78.84	473	5	
Average.																					
119.	Gravel...	1:2.4	1:2.01:4.10	8.1 Damp...	6	10	8 ¹⁰	10 ¹⁸	6	599	141.5	74.65	.000100	49.5	12,620	78.50	5.03	83.53	501	8	
120.	do...	1:2.4	1:2.01:4.10	8.1 ...do...	6	9	8 ¹⁰	11 ¹⁰	6	592	140.7	67.65	.000105	49.2	11,880	72.88	5.00	77.88	467	3	
121.	do...	1:2.4	1:2.01:4.10	8.1 ...do...	7	3	8 ¹⁰	11 ¹⁸	6	636	141.8	75.43	.000119	44.0	10,900	82.22	5.79	88.01	528	14	
Average.																					
134.	Limestone	1:2.4	1:2.01:3.91	11.0 Wet...	6	7	8 ¹⁰	11 ¹⁰	6	603	146.4	66.14	.000100	50.5	12,000	72.15	5.12	77.27	464	4	
135.	do...	1:2.4	1:2.01:3.91	11.0 ...do...	9	0	8	11 ¹⁰	8	824	144.5	59.26	.000092	49.1	6,000	71.12	8.87	79.99	490	14	
136.	do...	1:2.4	1:2.01:3.91	11.0 ...do...	7	8	8	11 ¹⁰	7	702	145.8	71.11	.000105	48.3	9,000	80.00	6.85	86.85	521	6	
Average.																					
144.	Limestone	1:2.4	1:2.01:3.91	10.0 Med...	7	3	8 ¹⁰	11 ¹⁰	6	658	144.0	82.68	.000118	48.1	12,000	90.20	5.93	96.13	577	9	
145.	do...	1:2.4	1:2.01:3.91	10.0 ...do...	8	0	8	11 ¹⁰	7	732	146.7	73.41	.000108	47.1	8,000	83.90	7.98	91.88	551	16	
258.	do...	1:2.4	1:2.01:3.91	10.0 ...do...	8	5	8 ¹⁰	11 ¹⁰	7	770	145.1	81.41	.000102	51.6	8,000	81.41	7.66	89.07	534	6	
Average.																					
158.	Limestone	1:2.4	1:2.01:3.91	8.6 Damp...	6	8	8	11 ¹⁰	6	621	149.2	84.84	.000127	47.5	15,000	90.90	5.23	96.13	577	21	
259.	do...	1:2.4	1:2.01:3.91	8.6 ...do...	8	3	8 ¹⁰	11 ¹⁰	7	762	149.4	92.61	.000128	48.6	9,000	92.61	7.86	100.47	603	0	
260.	do...	1:2.4	1:2.01:3.91	8.6 ...do...	6	7	8 ¹⁰	11 ¹⁰	6	613	147.3	97.41	.000137	47.4	16,200	97.41	5.20	102.61	616	14	
Average.																					
																			99.74	632	...

STRENGTH OF CONCRETE BEAMS.

TABLE 10.—*Compression tests of concrete cylinders and cubes accompanying beams.*
TESTED AT FOUR WEEKS.

Register No.	Aggregate.	Proportion.		Water (per cent.).	Consist-ency.	Cylinders.					Cubes.				Stress ratio of cylin- ders to cubes.	
		Volume.	Weight.			Dimensions (inches).		Weight (pounds per cubic foot).	Maxi- mum unit stress.	Initial modulus elasticity.	Range of linear values.	Dimensions (inches).		Weight (pounds per cubic foot).		Maxi- mum unit stress.
						Diam- eter.	Length.					Base.	Height.			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
18.....	Cinder.....	1:2.5:0.6	1:2.02:2.38	21.6	Wet.....	8.00	16.00		1,243	1,017,000	200	6.00×6.00	5.94		1,394	0.892
19.....	do.....	1:2.5:0.6	1:2.02:2.38	21.8	do.....	8.00	16.00		1,000	1,337,000	250	6.00×6.00	5.94		1,200	.833
21.....	do.....	1:2.5:0.6	1:2.02:2.38	21.6	do.....	8.00	16.00		1,000	1,355,000	350	6.00×6.00	6.00		1,173	.853
Average									1,081	1,236,000	270				1,256	.859
24.....	Cinder.....	1:2.5:0.6	1:2.02:2.38	19.4	Med.....	8.00	16.00		1,114	2,020,000	250	6.00×6.00	6.00		1,179	.945
28.....	do.....	1:2.06:5.40	1:2.07:2.54	20.4	do.....	8.00	16.00		1,250	1,000,000	250	6.00×6.00	6.25		1,093	1.144
29.....	do.....	1:2.06:5.40	1:2.07:2.54	20.4	do.....	8.00	16.00		1,240	1,035,000	300	6.00×6.00	6.13		1,302	.952
Average									1,201	1,352,000	270				1,191	1.014
37.....	Cinder.....	1:2.5:1.9	1:2.01:2.44	19.0	Damp.....	8.00	16.00		1,055	1,250,000	300	6.00×6.00	6.13		1,541	.685
38.....	do.....	1:2.5:1.9	1:2.01:2.44	19.0	do.....	8.00	16.00		1,210	1,390,000	250	6.00×6.00	6.13		1,304	.898
39.....	do.....	1:2.5:1.9	1:2.01:2.44	19.0	do.....	8.00	16.00		1,090	1,225,000	350	6.00×6.00	6.13		1,199	.909
Average									1,118	1,288,000	300				1,378	.821
53.....	Granite.....	1:2:4	1:2.01:3.82	9.2	Wet.....	8.00	16.00	149.3	3,093	3,690,000	700	6.00×6.00	6.00	144.0	3,318	.932
54.....	do.....	1:2:4	1:2.01:3.82	9.0	do.....	8.00	16.00	146.6	2,350	3,020,000	850	6.00×6.00	6.13	146.0	3,151	.746
55.....	do.....	1:2:4	1:2.01:3.82	9.0	do.....	8.00	16.00	150.4	2,607	4,000,000	800	6.00×6.00	6.13	148.9	3,000	.869
Average									148.8	3,570,000	780			146.3	3,156	.849
51.....	Granite.....	1:2:4	1:2.01:3.82	7.3	Med.....	8.00	16.00	150.9	3,990	4,100,000	1,000	6.00×6.00	6.00	153.0	4,063	.982
64.....	do.....	1:2:4	1:2.01:3.82	8.4	do.....	7.99	16.05	148.8	3,250	4,640,000	800	6.02×6.02	6.13	147.8	4,251	.765
65.....	do.....	1:2:4	1:2.01:3.82	8.4	do.....	8.07	16.19	146.6	3,199	3,510,000	1,000	6.03×6.03	6.14	146.1	3,954	.809
Average									3,480	4,083,000	930			149.0	4,069	.852
72.....	Granite.....	1:2:4	1:2.01:3.82	6.9	Damp.....	8.03	15.95	149.8	4,000	4,840,000	1,000	5.98×5.98	6.06	150.5	5,072	.789
73.....	do.....	1:2:4	1:2.01:3.82	6.9	do.....	8.04	16.14	148.7	4,000	4,960,000	1,000	6.03×6.03	6.05	147.3	3,780	1.058
78.....	do.....	1:2:4	1:2.01:3.82	6.9	do.....	8.02	15.97	148.9	4,000	4,860,000	950	5.99×5.99	6.03	145.8	4,703	.851
Average									4,000	4,860,000	980			147.9	4,518	.899
88.....	Gravel.....	1:2:4	1:2.01:4.10	9.5	Wet.....	8.02	16.24	141.1	2,336	3,850,000	800	5.98×5.98	6.18	141.7	2,757	.847
89.....	do.....	1:2:4	1:2.01:4.10	9.5	do.....	7.99	16.11	138.2	2,087	4,040,000	1,000	6.02×6.02	6.23	138.5	2,342	.891
90.....	do.....	1:2:4	1:2.01:4.10	9.7	do.....	7.99	16.22	141.6	1,758	3,470,000	800	6.04×6.04	6.22	139.0	1,799	.977
Average									140.3	3,787,000	870			139.7	2,299	.905

100.	Gravel	1:2.4	1:2.01:4.10	8.6	Med.	16.09	142.6	3,375	6,620,000	1,500	6.02×6.02	6.12	142.1	3,886	.869
101.	do	1:2.4	1:2.01:4.10	8.6	do	16.18	142.7	2,486	3,900,000	1,500	5.97×5.97	6.14	143.1	3,576	.685
102.	do	1:2.4	1:2.01:4.10	9.0	do	16.18	142.7	3,022	3,850,000	1,500	6.02×6.02	6.16	142.2	3,179	.981
Average															
112.	Gravel	1:2.4	1:2.01:4.10	7.6	Damp	16.04	142.7	2,961	3,875,000	1,500	6.02×6.02	6.09	142.9	3,547	.838
113.	do	1:2.4	1:2.01:4.10	7.6	do	16.15	141.7	3,437	4,640,000	1,000	6.02×6.02	6.07	142.9	4,581	.780
113.	do	1:2.4	1:2.01:4.10	7.6	do	16.08	140.9	2,392	3,840,000	1,200	6.03×6.03	6.07	144.9	4,565	.....
113.	do	1:2.4	1:2.01:4.10	7.6	do	16.08	142.9	3,377	3,730,000	1,400	5.97×5.97	6.02	147.1	4,689	.720
Average															
128.	Limestone	1:2.4	1:2.01:3.91	10.8	Wet	16.02	141.8	3,407	4,070,000	1,200	6.08×6.08	6.16	145.0	4,612	.735
129.	do	1:2.4	1:2.01:3.91	10.8	do	16.07	147.6	2,741	3,480,000	900	5.98×5.98	6.14	142.3	5,065	.541
130.	do	1:2.4	1:2.01:3.91	11.0	do	16.04	145.5	2,591	3,890,000	1,300	5.98×5.98	6.23	147.1	5,218	.497
Average															a 1.684
141.	Limestone	1:2.4	1:2.01:3.91	10.0	Med.	16.11	145.4	3,072	3,588,000	1,130	5.98×5.98	6.12	145.0	5,141	.519
142.	do	1:2.4	1:2.01:3.91	10.0	do	16.08	145.5	3,889	3,400,000	700	5.98×5.98	6.04	146.1	2,644	1.471
143.	do	1:2.4	1:2.01:3.91	10.0	do	16.04	145.9	2,458	3,700,000	800	6.02×6.02	6.14	143.8	3,315	.742
Average															.803
151.	Limestone	1:2.4	1:2.01:3.91	8.4	Damp	16.22	146.0	2,910	3,432,000	870	6.03×6.03	6.07	144.6	2,975	1.005
152.	do	1:2.4	1:2.01:3.91	8.4	do	16.07	146.2	3,171	4,025,000	800	5.98×5.98	6.05	147.8	3,948	.803
153.	do	1:2.4	1:2.01:3.91	8.4	do	16.12	150.8	2,749	4,720,000	500	5.98×5.98	6.06	149.3	4,392	.626
Average															.580
Average							148.7	2,884	4,257,000	830	5.98×5.98	6.06	148.5	4,760	.670

a Not included in average.

TABLE 10.—*Compression tests of concrete cylinders and cubes accompanying beams—Continued.*

TESTED AT THIRTEEN WEEKS.

Register No.	Aggregate.	Proportion.			Water (per cent).	Consistency.	Cylinders.				Cubes.				Stress ratio of cylinders to cubes.		
		Volume.		Weight.			Weight (pounds per cubic foot).	Max. unit stress.	Initial modulus of elasticity.	Range of linear values.	Dimensions (inches).		Weight (pounds per cubic foot).	Max. unit stress.			
		3	4								Diameter.	Length.				Base.	Height.
1	2				5	6	7	8	9	10	11	12	13	14	15	16	17
2	Cinder	1:2.4.86	1:2.02:2.29	22.15	Wet.	8.02	16.00	120.3	1,651	3,500,000	400	6.04×6.04	6.04	115.7	2,037	0.311	
3	do	1:2.4.79	1:2.02:2.25	22.3	do	8.02	15.88	117.2	1,963	1,740,000	600	6.04×6.04	6.09	114.8	2,086	.941	
9	do	1:2.4.79	1:2.02:2.25	22.0	do	8.01	16.13	111.9	1,678	2,730,000	300	6.02×6.03	6.01	115.8	1,923	.873	
Average.								116.5	1,764	2,657,000	430			115.4	2,015	.875	
3	Cinder	1:2.5.13	1:2.02:2.41	21.4	Med.	8.01	15.75	118.7	1,830	3,120,000	400	6.07×6.07	6.04	112.6	1,687	1.085	
33	do	1:2.5.21	1:2.01:2.45	21.0	do	8.00	15.99	114.5	1,643	2,030,000	300	5.99×6.04	6.04	110.3	2,145	.766	
34	do	1:2.5.21	1:2.01:2.45	20.0	do	8.01	16.02	113.7	1,984	1,675,000	500	6.11×6.12	6.07	110.3	1,732	1.146	
Average.								115.6	1,819	2,275,000	400			111.5	1,855	.999	
40	Cinder	1:2.5.19	1:2.01:2.44	19.0	Damp	8.00	16.15	113.6	1,725	1,940,000	500	5.97×6.05	6.07	114.3	2,009	.859	
41	do	1:2.5.19	1:2.01:2.44	19.0	do	8.06	16.15	112.5	1,790	1,460,000	400	6.03×6.06	6.15	114.4	1,906	.891	
42	do	1:2.5.19	1:2.01:2.44	18.9	do	8.07	16.03	111.4	1,662	1,505,000	500	5.99×6.03	6.15	114.8	1,769	.940	
Average.								112.5	1,726	1,635,000	470			114.5	1,861	.930	
56 ^a	Granite	1:2.4	1:2.01:3.82	8.7	Wet.	8.00	16.10	146.6	3,528	4,840,000	1,300	6.04×6.05	6.27	145.2	4,779	.738	
57	do	1:2.4	1:2.01:3.82	8.7	do	8.07	16.15	144.9	3,197	3,690,000	1,200	6.05×6.07	6.25	145.0	4,954	.645	
58	do	1:2.4	1:2.01:3.82	9.0	do	7.99	16.00	146.7	3,805	4,320,000	1,300	6.01×6.03	6.04	148.0	4,529	.840	
Average.								146.1	3,510	4,283,000	1,270			146.1	4,754	.741	
68	Granite	1:2.4	1:2.01:3.82	8.2	Med.	8.00	16.13	147.9	(b)	4,800,000	1,100	6.02×6.06	6.20	149.9	5,099	.....
69	do	1:2.4	1:2.01:3.82	8.2	do	8.03	16.24	145.8	(c)	4,780,000	1,200	6.01×6.01	6.14	148.0	5,372	.....
70	do	1:2.3.97	1:2.01:3.78	8.6	do	8.01	16.01	147.5	3,777	4,660,000	1,100	6.03×6.06	6.11	146.3	4,504	.....
Average.								147.1		4,747,000	1,130			148.1	4,992	.....
79	Granite	1:2.4	1:2.01:3.82	6.9	Damp	8.05	16.09	148.2	(d)	4,340,000	1,300	6.01×6.02	6.12	148.3	(e)	.....
80	do	1:2.4	1:2.01:3.82	7.0	do	8.03	16.11	148.3	(c)	5,290,000	1,200	5.98×6.02	6.03	149.3	5,445	.....
81	do	1:2.4	1:2.01:3.82	7.0	do	8.08	16.10	147.6	(f)	4,470,000	1,000	6.02×6.06	6.11	144.4	(g)	
Average.								148.0		4,697,000	1,170			147.3		

RESULTS OF TESTS.

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91.....	Gravel.....	1:2:4	1:2:01:4:10	9.7	Wet.....	8.01	16.37	136.6	2,699	5,360,000	1,000	Cubes not tested.							
92.....	do.....	1:2:4	1:2:01:4:10	9.9	do.....	8.01	16.16	140.9	2,967	5,000,000	1,200								
93.....	do.....	1:2:4	1:2:01:4:10	9.9	do.....	8.03	16.37	136.7	3,195	4,310,000	1,100								
Average.....								140.1	2,954	4,890,000	1,100								
103.....	Gravel.....	1:2:4	1:2:01:4:10	9.0	Med.....	8.09	16.10	140.7	(A)	5,920,000	900	Cubes not tested.							
104.....	do.....	1:2:4	1:2:01:4:10	9.0	do.....	8.05	16.13	142.3	43,930	5,300,000	1,200								
105.....	do.....	1:2:4	1:2:01:4:10	9.0	do.....	8.03	16.17	141.1	2,765	4,380,000	1,900								
Average.....								141.4	-	5,200,000	1,330								
116.....	Gravel.....	1:2:4	1:2:01:4:10	7.6	Damp.....	8.02	16.15	145.1	(J)	5,140,000	1,400	Cubes not tested.							
117.....	do.....	1:2:4	1:2:01:4:10	8.0	do.....	8.01	16.16	146.4	(K)	5,140,000	1,400								
118.....	do.....	1:2:4	1:2:01:4:10	8.1	do.....	8.03	16.18	143.4	(C)	5,200,000	1,100								
Average.....								145.0	-	5,160,000	1,300								
131.....	Limestone.....	1:2:4	1:2:01:3:91	11.0	Wet.....	8.05	16.23	142.0	3,367	3,700,000	1,000	Cubes not tested.							
132.....	do.....	1:2:4	1:2:01:3:91	11.0	do.....	8.00	16.12	145.0	3,441	4,240,000	700								
133.....	do.....	1:2:4	1:2:01:3:91	11.0	do.....	7.99	16.10	145.5	3,318	4,010,000	1,000								
Average.....								144.2	3,385	3,983,000	900								
126.....	Limestone.....	1:2:4	1:2:01:3:91	10.4	Med.....	8.03	16.16	147.0	3,508	3,800,000	1,000	Cubes not tested.							
127.....	do.....	1:2:4	1:2:01:3:91	10.4	do.....	8.05	16.11	146.2	3,458	3,960,000	1,100								
140.....	do.....	1:2:4	1:2:01:3:91	10.0	do.....	8.02	16.27	143.5	3,445	4,130,000	800								
Average.....								145.6	3,470	3,963,000	970								
153.....	Limestone.....	1:2:4	1:2:01:3:91	8.4	Damp.....	8.02	16.41	146.7	(J)	4,680,000	1,200	Cubes not tested.							
154.....	do.....	1:2:4	1:2:01:3:91	8.4	do.....	8.00	16.22	148.3	(B)	4,500,000	1,000								
155.....	do.....	1:2:4	1:2:01:3:91	8.4	do.....	8.02	16.20	146.0	(J)	4,800,000	1,000								
Average.....								146.0	-	4,660,000	1,070								

a Cylinder spalled before test.
 b Cylinder did not fail at 3,979 unit stress.
 c Cylinder did not fail at 3,950 unit stress.
 d Cylinder did not fail at 3,929 unit stress.
 e Cube did not fail at 5,528 unit stress
 f Cylinder did not fail at 3,900 unit stress.
 g Cube did not fail at 5,453 unit stress.
 h Cylinder did not fail at 3,891 unit stress.
 i Cylinder broke after several minutes under load.

j Cylinder did not fail at 3,859 unit stress.
 k Cylinder did not fail at 3,969 unit stress.
 l Cubes 17 weeks old.
 m Cube did not fail at 5,447 unit stress.

TABLE 10.—*Compression tests of concrete cylinders and cubes accompanying beams—Continued.*

TESTED AT TWENTY-SIX WEEKS.

Register No.	Aggregate.	Proportion.		Water (per cent).	Consistency.	Cylinders.				Cubes.				Stress ratio of cylinders to cubes.		
		Volume.	Weight.			Dimensions (inches).		Weight (pounds per cubic foot).	Maxim. unit stress.	Initial modulus of elasticity.	Range of linear values.	Dimensions (inches).			Weight (pounds per cubic foot).	Maxim. unit stress.
						Diameter.	Length.					Base.	Height.			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
12.....	Cinder.....	1:2.4.79	1:2.02:2.25	22.4	Wet.....	7.99	15.95	113.2	1,872	1,720,000	500	6.00×6.00	6.00	114.0	2,350	0.797
15.....	do.....	1:2.4.79	1:2.02:2.25	22.4	do.....	8.00	16.11	113.9	2,090	1,580,000	800	6.00×6.00	6.00	115.0	2,124	.984
16.....	do.....	1:2.5.06	1:2.02:2.38	21.3	do.....	7.98	16.02	114.6	2,100	1,530,000	1,000	6.00×6.00	6.00	115.0	2,486	.845
Average.....								113.9	2,021	1,610,000	770			114.7	2,320	.875
5.....	Cinder.....	1:2.4.79	1:2.02:2.25	21.7	Med.....	8.01	15.85	113.4	2,461	1,680,000	1,200	6.01×6.03	6.03	115.7	2,950	.841
3.....	do.....	1:2.4.79	1:2.02:2.25	21.7	do.....	7.98	15.91	116.2	2,132	1,535,000	700	6.00×5.99	6.03	116.7	2,633	.810
35.....	do.....	1:2.5.21	1:2.01:2.45	20.0	do.....	8.00	16.10	113.4	1,995	1,640,000	600	6.03×6.03	6.06	111.9	2,712	.736
Average.....								114.3	2,203	1,618,000	830			114.8	2,765	.796
43.....	Cinder.....	1:2.5.19	1:2.01:2.44	19.0	Damp.....	8.02	16.16	112.2	1,940	1,300,000	700	6.04×6.04	6.02	113.1	2,310	.840
44.....	do.....	1:2.5.19	1:2.01:2.44	19.0	do.....	8.01	16.02	114.2	1,895	1,245,000	600	6.04×6.03	6.14	109.2	2,434	.779
45.....	do.....	1:2.5.19	1:2.01:2.44	18.5	do.....	7.98	16.10	114.8	2,001	1,600,000	600	6.14×6.02	6.02	115.5	2,720	.736
Average.....								113.7	1,945	1,382,000	630			112.6	2,488	.785
59.....	Granite.....	1:2.4	1:2.01:3.82	9.0	Wet.....	8.03	15.81	147.6	(a)	4,000,000	2,000	6.03×6.00	6.00	146.3	4,768	.....
60.....	do.....	1:2.4	1:2.01:3.82	8.8	do.....	7.99	15.90	147.1	(b)	4,040,000	1,400	6.01×6.01	6.03	145.8	4,859	.....
61.....	do.....	1:2.4	1:2.01:3.82	9.0	do.....	8.02	16.02	146.2	(c)	4,130,000	1,700	6.01×6.02	6.03	157.4	4,633	.....
Average.....								148.0		4,057,000	1,700			149.8	4,753	.....
71.....	Granite.....	1:2.3.97	1:2.01:3.78	8.6	Med.....	8.02	16.08	146.8	(d)	4,020,000	2,000	6.13×6.09	6.00	144.7	4,814	.....
74.....	do.....	1:2.4	1:2.01:3.82	8.4	do.....	8.00	16.11	147.5	(e)	3,800,000	2,200	6.00×5.98	6.12	149.5	4,892	.....
75.....	do.....	1:2.4	1:2.01:3.82	8.4	do.....	8.00	16.10	147.1	(f)	3,920,000	2,100	6.06×6.01	6.17	145.2	5,142	.....
Average.....								147.1		3,913,000	2,100			146.5	4,949	.....
82.....	Granite.....	1:2.4	1:2.01:3.82	7.0	Damp.....	8.02	16.11	146.9	(c)	4,700,000	2,000	6.00×6.06	6.00		5,410	.....
83.....	do.....	1:2.4	1:2.01:3.82	7.0	do.....	8.01	16.11	150.3	(g)	4,310,000	2,300	6.00×6.00	6.08	149.0	(f)	.....
84.....	do.....	1:2.4	1:2.01:3.82	7.1	do.....	8.00	16.02	146.1	(h)	4,220,000	2,000	6.02×6.02	6.04	147.0	5,519	.....
Average.....								146.8		4,430,000	2,100			148.0		.....
94.....	Gravel.....	1:2.4	1:2.01:4.10	9.9	Wet.....	8.00	16.09	138.4	A3,461	4,090,000	1,900	6.00×6.00	6.21	137.2	3,793	.913
95.....	do.....	1:2.4	1:2.01:4.10	9.9	do.....	8.01	16.15	139.1	3,431	3,660,000	2,200	6.05×6.01	6.22	138.5	3,699	.927
96.....	do.....	1:2.4	1:2.01:4.10	9.9	do.....	8.01	16.15	138.3	3,565	4,400,000	1,100	6.00×6.04	6.17	138.1	3,949	.903
Average.....								138.6	3,486	4,050,000	1,730			137.9	3,814	.914

RESULTS OF TESTS.

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106.	Gravel.	1:2:4	1:2:01:4.10	9.1	Med.	8.01	16.17	142.4	(e)	4,700,000	2,400	6.00×6.00	6.15	142.5	5,176
107.	do.	1:2:4	1:2:01:4.10	9.1	do.	8.00	16.14	142.7	(g)	4,740,000	(f)	6.03×6.03	6.20	140.9	4,810	.....
108.	do.	1:2:4	1:2:01:4.10	9.0	do.	8.01	16.12	143.9	(e)	4,490,000	2,600	6.06×6.06	6.02	142.6	4,439	.....
Average								143.0		4,660,000	2,500			142.0	4,808	.....
119.	Gravel.	1:2:4	1:2:01:4.10	8.1	Damp	8.00	16.02	145.9	(d)	5,400,000	2,300	6.00×6.00	6.00	144.0	5,472	.....
120.	do.	1:2:4	1:2:01:4.10	8.1	do.	8.03	16.02	147.0	(g)	4,490,000	1,700	6.00×6.00	6.00	144.0	4,972	.....
121.	do.	1:2:4	1:2:01:4.10	8.1	do.	8.00	16.00	147.5	(g)	4,740,000	2,400	6.00×6.00	6.00	146.0	4,208	.....
Average								146.8		4,873,000	2,130			144.7	4,884	.....
134.	Limestone.	1:2:4	1:2:01:3.91	11.0	Wet.	8.02	16.00	144.3	3,062	3,980,000	1,600	6.00×6.00	6.00	148.0	3,167	.967
135.	do.	1:2:4	1:2:01:3.91	11.0	do.	8.00	16.03	145.8	3,113	3,080,000	1,600	6.00×6.00	6.00	144.0	3,860	.807
136.	do.	1:2:4	1:2:01:3.91	11.0	do.	8.03	16.06	143.4	3,473	3,210,000	1,800	6.00×6.00	6.00	148.0	3,354	1.035
Average								144.5	3,216	3,423,000	1,670			146.7	3,460	.936
144.	Limestone.	1:2:4	1:2:01:3.91	10.0	Med.	8.00	16.05	146.7	3,567	4,030,000	1,500	6.00×6.00	6.00	150.0	3,300	1.081
145.	do.	1:2:4	1:2:01:3.91	10.0	do.	8.02	16.13	145.2	3,902	3,640,000	2,000	6.00×6.00	6.00	148.0	3,443	1.133
258.	do.	1:2:4	1:2:01:3.91	10.0	do.	8.00	16.06	146.8	3,605	4,160,000	1,200	6.01×6.01	6.07	147.3	4,935	.731
Average								146.2	3,691	3,943,000	1,570			148.4	3,896	.982
158.	Limestone.	1:2:4	1:2:01:3.91	8.6	Damp	8.13	16.13	145.7	(f)	3,690,000	2,000	6.00×6.00	6.00	150.0	4,218	.....
259.	do.	1:2:4	1:2:01:3.91	8.6	do.	7.99	16.19	149.0	(b)	4,400,000	1,400	5.98×6.05	6.09	148.0	5,325	.....
260.	do.	1:2:4	1:2:01:3.91	8.6	do.	8.00	16.19	148.4	(d)	4,220,000	1,900	6.01×5.99	6.03	147.8	5,532	.....
Average								147.7		4,310,000	1,770			148.6	5,025	.....

^a Cylinder did not break at 3,950 unit stress.
^b Cylinder did not break at 3,989 unit stress.
^c Cylinder did not break at 3,959 unit stress.
^d Cylinder did not break at 3,979 unit stress.
^e Cylinder did not break at 3,969 unit stress.
^f Cube did not break at 5,556 unit stress.
^g Cylinder did not break at 3,978 unit stress.
^h Cylinder stress approximate.
ⁱ Machine vibrated compressometer.
^j Cylinder did not break at 3,858 unit stress.

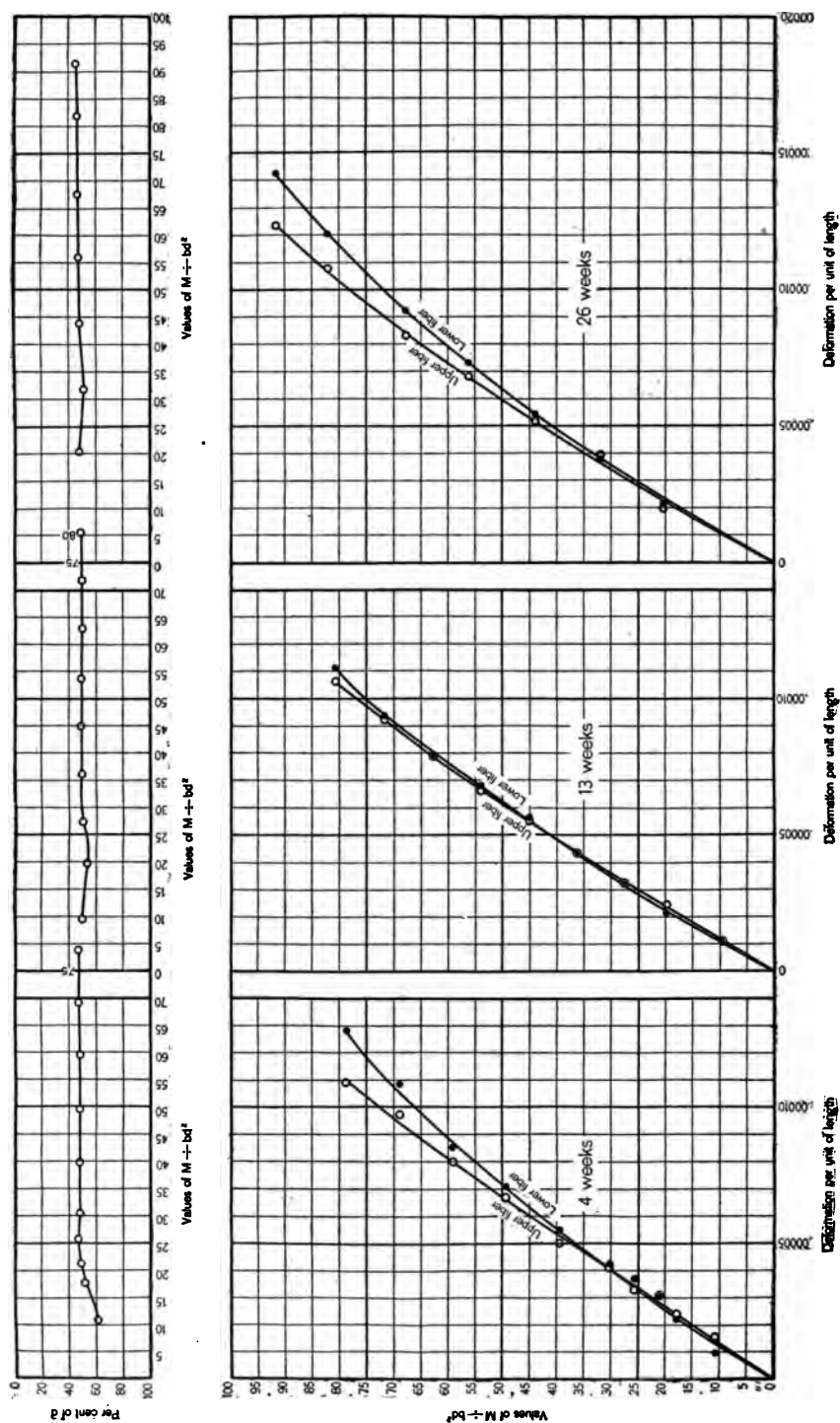


FIG. 11.—Characteristic deformation curves for flexure, granite concrete of medium consistency; ages 4, 13, and 26 weeks.

BEAMS OF VARIABLE SPAN.

The detailed results of tests of the beams of variable span are given in Table 9 (pp. 42-47), and some of the results are graphically shown in figs. 2-5. The information given in columns 1-14, 17, 18, 21, and 22 of the table is identical in character with that given in the corresponding columns of Table 8.

Column 15 contains the unit elongation of the lower outer fiber for the applied load only, since the short beams were not suspended for zero total deformations as were the long beams. The values of the unit elongation, including that due to the weight of the beam and the deformeters, may be approximated by increasing the values in column 15 by an amount obtained from the averages in column 12, Table 8, on the assumption that the elongation is directly proportional to the values for $\frac{M}{bd^2}$, which is approximately true for values below those for the weight of the beam plus the weight of the deformeters. The values for $\frac{M}{bd^2}$ for own weight and deformeters are given in column 19 and, as may be seen by comparing with the maximum total values in column 20, are in the majority of cases but a small percentage of the total.

Column 16 gives the position of the neutral axis in percentage of the depth below the top of the beam. These values are not strictly comparable with those in column 15, Table 8, since they are based on deformations due to the applied load alone.

CYLINDERS AND CUBES.

The detailed results of the compression tests of cylinders 8 inches in diameter by 16 inches in length and of 6-inch cubes are given in Table 10. Some of the results are also graphically shown in figs. 2-9.

Columns 1-6 contain the same kind of information as is given for the beams in the corresponding columns of Tables 8 and 9.

Columns 7 and 8 and columns 13 and 14 show the dimensions of the cylinders and cubes, respectively, in inches.

Columns 9 and 15 show the weight in pounds per cubic foot, as figured from the dimensions and the actual weight of each cylinder and cube when tested.

Columns 10 and 16 show the ultimate strength of each cylinder and cube in pounds per square inch.

The initial modulus of elasticity (given in column 11) was obtained from a curve showing the relation between the unit gross deformation and the compressive stress in pounds per square inch, by drawing a line tangent to the curve at the origin or where possible coincident with the straight line or initial part of the curve. The range in pounds

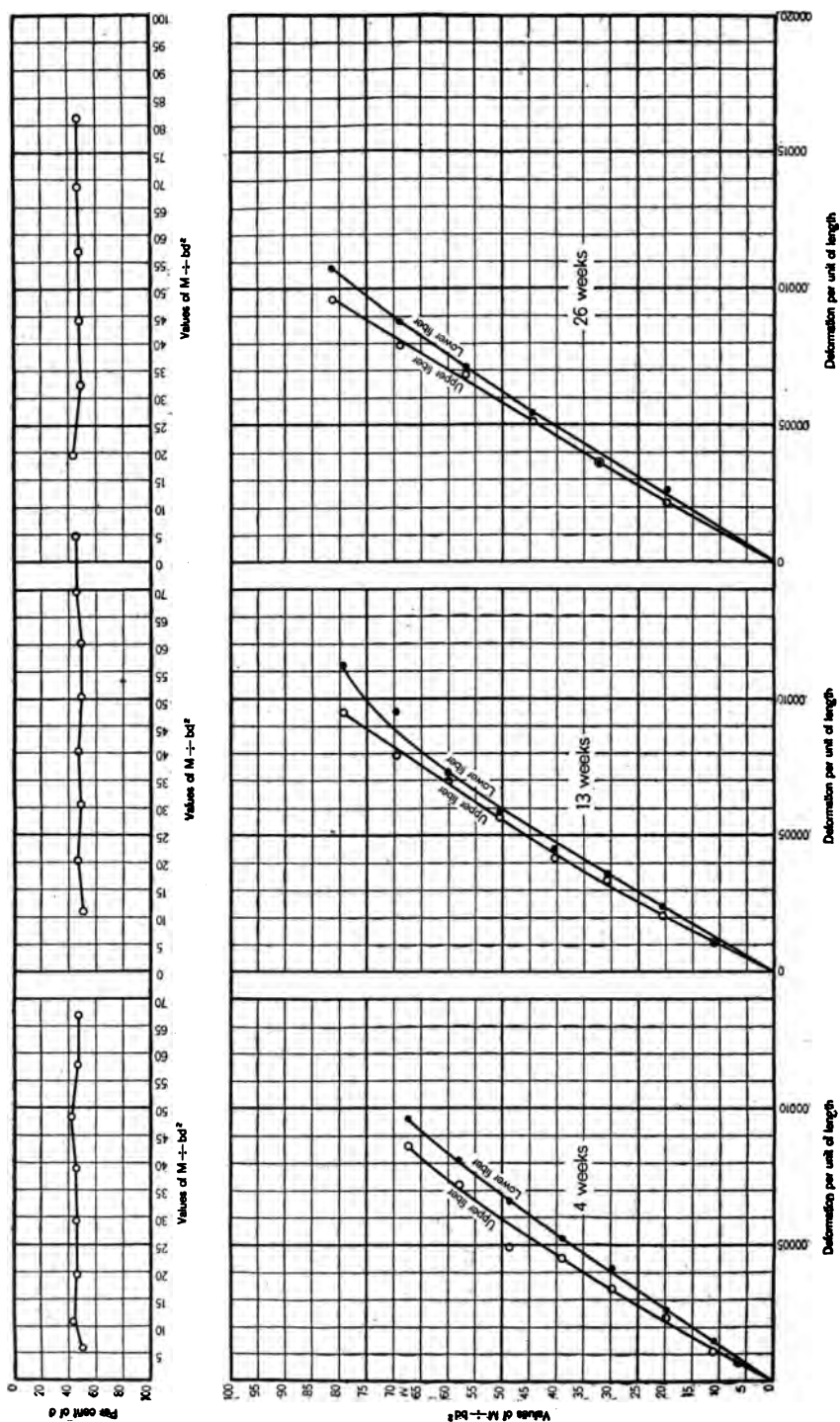


Fig. 12.—Characteristic deformation curves for flexure, gravel concrete of medium consistency; ages 4, 13, and 26 weeks.

per square inch within which the line drawn coincides with the curve is also shown (column 12).

Column 17 gives the ratio of the ultimate strength of the cylinders to that for the cubes.

It is to be regretted that the capacity of the machines composing the equipment was exceeded by the strength of many of the cylinders and cubes at the time these tests were made, preventing the accurate determination of the actual growth of strength with age. There is, however, in almost every case a substantial increase in strength with age.

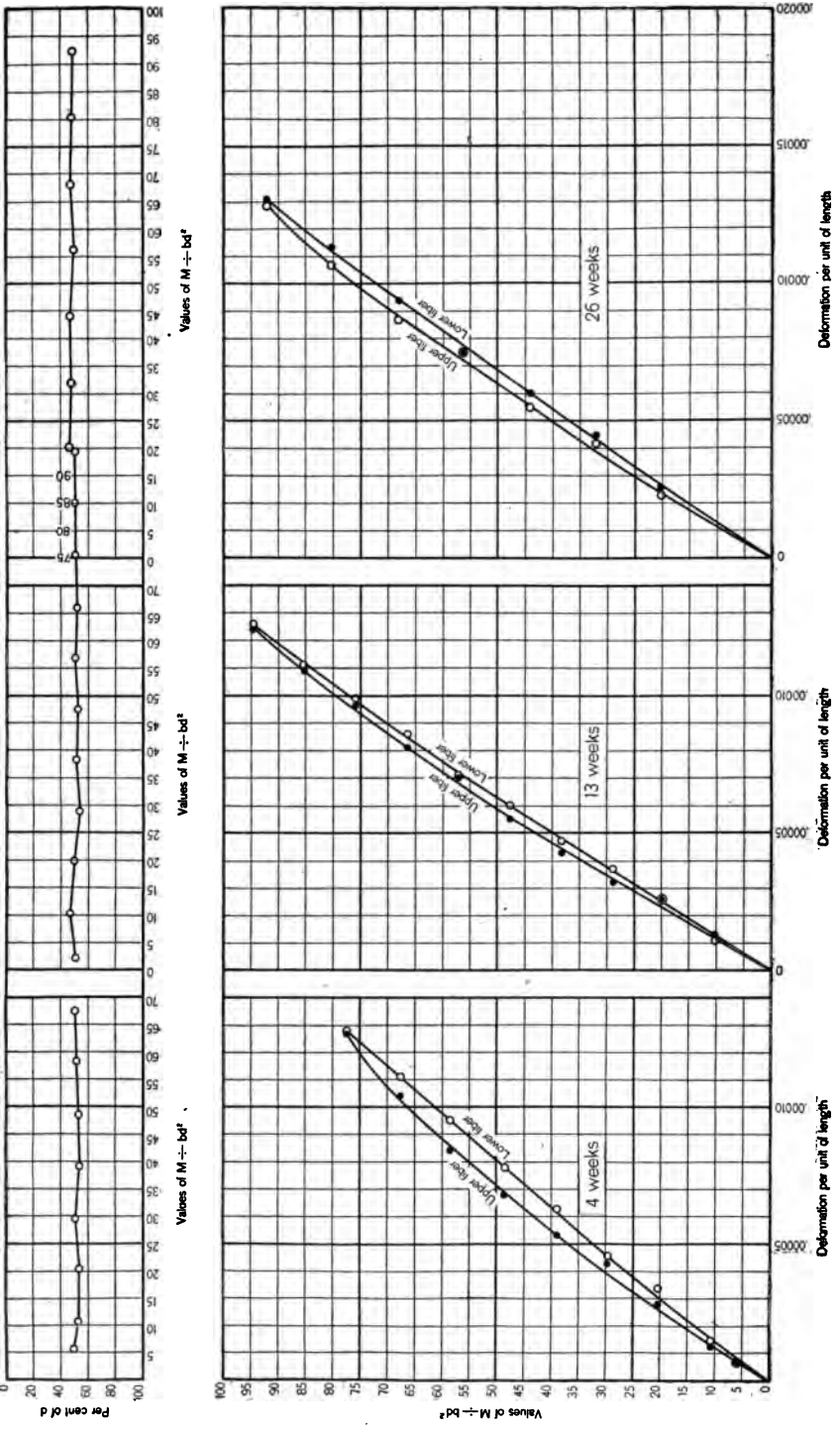
The effect of consistency on the strength is much more noticeable, and leads to much more uniform results for the cubes and cylinders than for the beams. This would lead one to believe that the effect of consistency is much more noticeable and much more uniform on the compressive strength of concrete than on the tensile strength.

Owing to a breakdown of the engine it became necessary to apply the load by hand for a number of tests. The beams and cylinders, being deemed the most important, were tested in this way, but because of the difficulty of turning the gears of the testing machine by hand the testing of the cubes was omitted.

ILLUSTRATIVE DIAGRAMS.

Figs. 2, 3, 4, and 5 show graphically the effect of age and consistency on the ultimate compressive strength of cinder, granite, gravel, and limestone concretes, as obtained from the tests on the cylinders and cubes and in the modulus of rupture as given by the tests in the beams of constant and variable span.

Figs. 6, 7, 8, and 9 show graphically several characteristic compression-stress deformation curves obtained from tests on the cylinders, while figs. 10, 11, 12, and 13 show the deformation curves for a few of the beams of 12-foot span.



SURVEY PUBLICATIONS ON TESTS OF STRUCTURAL MATERIALS.

The following reports, published by the Geological Survey, relate to structural materials, etc.:

- BULLETIN 238. Economic geology of the Iola quadrangle, Kansas, by G. I. Adams, Erasmus Haworth, and W. R. Crane. 1904. 8°. 83 pp., 11 pls.
- BULLETIN 243.* Cement materials and industry of the United States, by E. C. Eckel. 1905. 8°. 395 pp., 15 pls. 65c.
- BULLETIN 260.* The American cement industry, pp. 496-505. 1905. 40c.
- BULLETIN 324. The San Francisco earthquake and fire of April 18, 1906, and their effects on structures and structural materials, by G. K. Gilbert, R. L. Humphrey, J. S. Sewell, and Frank Soulé. 1907. 170 pp.
- BULLETIN 329. Organization, equipment, and operation of the structural-materials testing laboratories at St. Louis, Mo., by R. L. Humphrey. 1908. 85 pp.
- BULLETIN 331. Portland cement mortars and their constituent materials; results of tests made at the structural-materials testing laboratories, St. Louis, Mo., by R. L. Humphrey and William Jordan, jr. 1908. 130 pp.
- WATER-SUPPLY PAPER 143. Experiments on steel-concrete pipes on a working scale, by J. H. Quinton. 1905. 8°. 61 pp., 4 pls.
- MINERAL RESOURCES U. S. FOR 1901,* 1902, 1903,* 1904, AND 1905.* Cement. A series of annual articles on the cement industry and the production of cement in the United States, by L. L. Kimball. 50c. for each volume.
- MINERAL RESOURCES U. S. FOR 1906, pp. 897-905. Advances in cement technology, 1906, by E. C. Eckel.

Reports marked with an asterisk (*) are out of stock, but may be had from the Superintendent of Documents, Washington, D. C., at the prices named. The others will be sent free to anyone interested on application to The Director, United States Geological Survey, Washington, D. C.





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